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## A quantitative analysis of surgical capacity in Santa Cruz, Bolivia

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### ABSTRACT

**Objectives:** This investigation aimed to document surgical capacity at public medical centers in a middle-income Latin American country using the Surgeons OverSeas (SOS) Personnel, Infrastructure, Procedures, Equipment, and Supplies (PIPES) survey tool.

**Materials and methods:** We applied the PIPES tool at six urban and 25 rural facilities in Santa Cruz, Bolivia. Outcome measures included the availability of items in five domains (Personnel, Infrastructure, Procedures, Equipment, and Supplies) and the PIPES index. PIPES indices were calculated by summing scores from each domain, dividing by the total number of survey items, and multiplying by 10.

**Results:** Thirty-one of the 32 public facilities that provide surgical care in Santa Cruz were assessed. Santa Cruz had at least 7.8 surgeons and 2.8 anesthesiologists per 100,000 population. However, these providers were unequally distributed, such that nine rural sites had no anesthesiologist. Few rural facilities had blood banking (4/25), anesthesia machines (11/25), postoperative care (11/25), or intensive care units (1/25). PIPES indices ranged from 5.7–13.2, and were significantly higher in urban (median 12.6) than rural (median 7.8) areas ( $P < 0.01$ ).

**Conclusions:** This investigation is novel in its application of a Spanish-language version of the PIPES tool in a middle-income Latin American country. These data document substantially greater surgical capacity in Santa Cruz than has been reported for Sierra Leone or Rwanda, consistent with Bolivia's development status. Unfortunately, surgeons are limited in rural areas by deficits in anesthesia and perioperative services. These results are currently being used to target local quality improvement initiatives.

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## 1. Introduction

Surgical care is increasingly recognized as an essential component of public health [1,2]. Moreover, evidence suggests that investment in surgical care can be cost-effective compared with established priorities in global health, such as the treatment of human immunodeficiency virus/AIDS and malaria [3]. These data buttress the idea that “horizontal” interventions to support general health care systems may be more effective and sustainable than programs that target individual diseases [4]. As surgery is incorporated into broad-based improvements in healthcare systems in low- and middle-income countries, it is critical to assess currently available surgical services and needs in these settings.

To this end, tools to measure deficiencies in surgical and anesthetic care have been developed and deployed in sub-Saharan Africa and Asia [5–17]. However, to date, few assessments of surgical capacity have been conducted in the Americas or in middle-income countries [18]. Data from diverse settings are necessary to place individual country reports in context and guide global surgical development priorities.

Bolivia is a large, landlocked, geographically and demographically diverse South American country. The World Bank classifies it as a lower-middle-income country, meaning it has a gross national income between \$1026 and \$4035 per capita. It is the continent’s second least developed country after Guyana [19], as measured by the Inequality-Adjusted Human Development Index (IHDI) produced by the United Nations Human Development Program. The IHDI was first reported by the World Health Organization (WHO) in 2010, and corrects traditional measures of development to account for inequality and better reflect opportunities for people to lead fulfilling lives. Of note, Latin America has the worst inequality in income but not health [19], highlighting a need to understand how this region differs from others studied.

Santa Cruz is the largest, most populous, and wealthiest of Bolivia’s nine departments (states); despite its prosperity, it is also highly inequitable and marked by rural-urban wealth gradients [20]. Santa Cruz is home to 2.8 million residents [21] and is composed of 15 provinces situated in the tropical lowlands of Eastern Bolivia, including the country’s geographic descent into the Amazon basin. The capital city of Santa Cruz de la Sierra has a population of 1.6 million and is the largest city in Bolivia [22].

The present investigation used the Personnel, Infrastructure, Procedures, Equipment, and Supplies (PIPES) tool developed by Surgeons OverSeas (SOS) [23] to assess surgical capacity at public medical centers in the state of Santa Cruz, Bolivia. We aimed to demonstrate the utility of a Spanish-language version of the PIPES tool in a middle-income Latin American country. These data will enable comparisons between facilities and help monitor changes in capacity over time, as future improvements are made to Bolivia’s health care systems. Surveys of surgical capacity such as this also serve to stimulate broader discussions of global surgical needs.

## 2. Methods

### 2.1. The PIPES tool

The PIPES tool was developed by modifying the WHO Tool for the Situational Analysis of Emergency and Essential Surgical Care (the WHO tool) in order to simplify administration of the assessment and to produce an index that facilitates interpretation of its results [23]. The modifications incorporated into the PIPES tool address several shortcomings of the WHO that were subsequently identified by Osen *et al.* (2011) [24]. These changes involved adopting a dichotomous response format to reduce ambiguity, reporting the absolute number of operating rooms at each site, streamlining individual questions, and reducing the number of survey items from 256–105. Since its creation, the PIPES tool has been successfully applied in Sierra Leone [23] and Nigeria [16]. It is publically available on the (SOS) website (<http://www.humanitariansurgery.org/page4/page4.html>). For the present investigation, the PIPES tool was translated into Spanish with the help of bilingual local physicians and nurses and then back-translated to English by a third-party to ensure validity and clarity.

The PIPES tool consists of five sections that were assessed for each facility studied. The Personnel score was calculated by summing the total number of surgeons and surgical subspecialists, non-surgeon doctors with surgical skills, anesthesiologists, and nurse anesthetists. The Infrastructure score was calculated by assigning one point for each of 13 data items (e.g., running water, electricity, emergency department, etc.) that were reported as “always available” and adding the number of functioning operating rooms to this subtotal. The Procedures score was calculated by assigning one point for each of the 40 procedures of interest that were performed at a given facility (e.g., caesarean section, appendectomy, hernia repair, etc.). An Equipment score was calculated by adding one point for each of the 22 equipment items assessed, and a Supplies score was calculated by adding one point for each of the 25 supplies that were reported as always available.

### 2.2. Site selection and data collection

In December 2011, the PIPES tool was provided to the state health service (Servicios Departamentales de Salud; SEDES) of Santa Cruz. A partnership between SOS and SEDES was subsequently formed with the goal of providing a standardized and replicable assessment of departmental surgical services. Public healthcare in Bolivia is organized into urban and rural health networks. Most rural health networks correspond to the provinces of each department. The department of Santa Cruz has four urban and 15 rural health networks composed of hospitals and clinics that are organized into first-, second-, and third-level health centers. Small “health posts,” including some that are not staffed by a physician, and others staffed by one or more physicians and nurses, are classified as first-level. To be classified as second-level, larger “health centers” serve as points of referral in rural areas and must be staffed by physicians from at least four

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