Impact Surgery

Brief research paper

e-ISSN: 3033-4470

Geospatial analysis of first, second, and third level hospitals in a surgical network in the low and middle income countries

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Abstract

Introduction: Distance from a healthcare facility is a barrier in access to surgery. Methodologies to evaluate the population covered by a hospital are time consuming and costly. The aim of this study was to analyse the population density around hospitals to pragmatically evaluate their access while comparing differences between hospital types.

Methods: This analysis was conducted in the hospitals that participated in an international cohort study on inguinal hernia patients (HIPPO study). Hospitals located in low and middle income countries were eligible for inclusion and were classified as first-referral, secondary, tertiary level hospitals. For each hospital, location and GPS coordinates were reported in maps. The population density within a 5km, 40km and 80km radius was calculated. The medians and interquartile range of the population densities were calculated in two stages: considering each hospital and considering the number of patients recruited.

Results: This analysis included 326 hospitals: 38 first-referral, 84 secondary and 204 tertiary level hospitals. For the 5km distance, the population density increased from first referral to tertiary hospitals (median of population density 1776, 3439 and 6979, respectively). In 40km and 80km radius, the same trend was observed (351, 300 and 888 for 40km and 294, 197 and 462 for 80km). When adjusting and weighting the patients recruited for the study, the differences became more evident.

Discussion: This analysis showed that in less densely populated areas first-referral hospitals predominate. The methods described can be used in other studies to evaluate the population that can be covered by different healthcare facilities.

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Cite as: Matei, A., Mulliez, A., Alexander, P., Bhangu, A., Boumas, N., Gyamfi, F. E., ... Nepogodiev , D. Geospatial analysis of first, second, and third level hospitals in a surgical network in the low and middle income countries. *Impact Surgery*, 1(6), 236–239. https://doi.org/10.62463/surgery.107

Introduction

According to the World Health Organisation (WHO), at least 50% of the world's people lack full coverage of essential health services [1]. Surgery is one essential health service and the proportion of the population that can access, within 2 hours, a facility that is able to deliver the Bellwether Procedures is one of the Global surgery indicators. A target of 80% coverage was established by 2030 but the evidence tracking the progress made is immature [2]. This is mainly justified by the time-consuming methodologies employed so far and the use of paid and complex software. Although a country analysis would assess the indicator directly, measuring population density around the hospital could be used as a surrogate of this indicator [3 4]. The aim of this study was to analyse the population density around hospitals to pragmatically evaluate their access while comparing differences between hospital types.

Methods

Hospitals data

The hospitals eligible for this analysis were the ones that took part in HIPPO study, a prospective, international, observational study that collected data from Jan 30 to May 21, 2023 of all patients undergoing inguinal hernia repair. Hospitals from low and middle income countries were included. Three level of hospitals were defined: (i) first-referral, hospitals with few specialties, mainly internal medicine, obstetrics and gynaecology, paediatrics and general surgery; (ii) secondary, hospitals with 5 to 10 clinical specialties, usually with 200 to 800 beds; and (iii) tertiary, highly specialised staff and technical equipment, and clinical services highly differentiated by function. Each hospital was classified by the hospital lead in the hospital questionnaire.

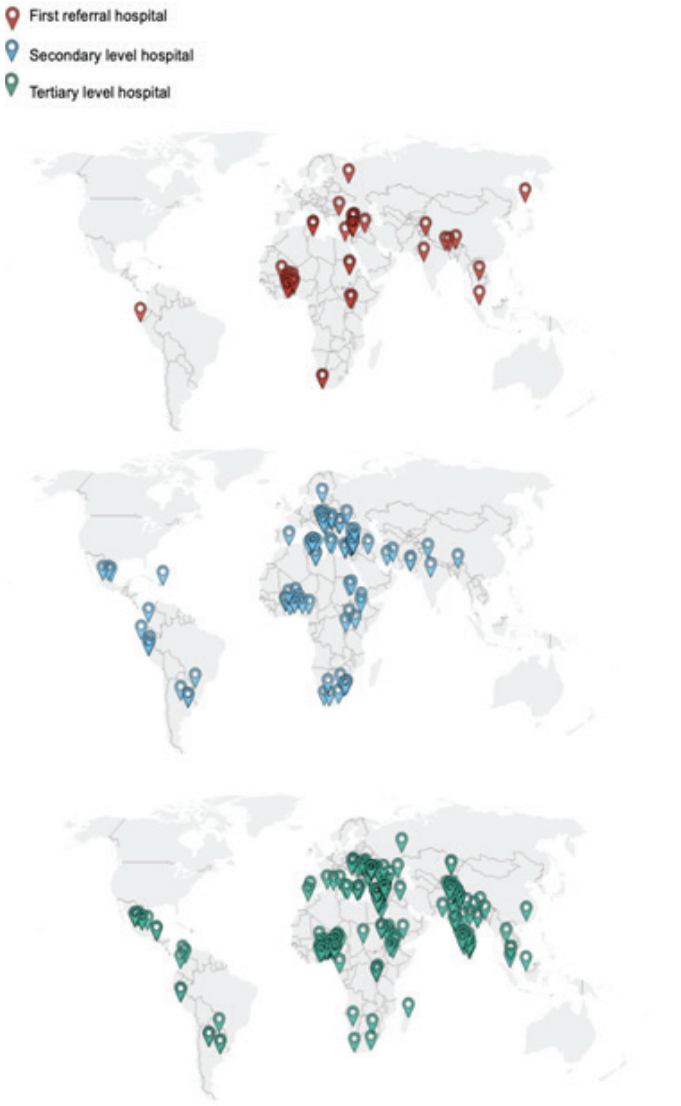
Population density around the hospital

For each hospital, location and GPS coordinates were identified. The GPS coordinates of the hospitals were extracted from an online server (https://www.google.com/maps). To solve any uncertainties related to the location of the hospital, national leads were approached to confirm GPS coordinates. The population density within a 5km, 40km and 80km radius of each hospital was calculated using an existing online tool (https://tomforth.co.uk/circlepopulations/). These distances were chosen as a surrogate of access to the hospital. The 5km distance reflected a walking distance from the hospital and the urbanisation of the area. The 40km distance reflected a 2h drive assuming an average driving speed of 20 km/h. The 80km distance reflected a 2h drive assuming an average driving speed of 40km/h. The medians and interquartile range of population density for each of these distances were calculated in two analyses. The first analysis mapped the population density to each hospital (hospital weighted). The second analysis mapped the population density to each patient (patients weighted). The three hospital types were compared. All analyses were done in Excel and R (version 4.0.2).

Mapping of hospitals

To report the exact location of each included hospital, maps were created using an online software (DataWrapper). Two maps were used to report the hospital's data: symbol and locator map. The symbol map was used to highlight the differences in the 5km population density around each hospital. The locator map was used to identify the exact location of each hospital.

Figure 1: Map of the location of the first referral, secondary and tertiary hospitals in low and middle income countries



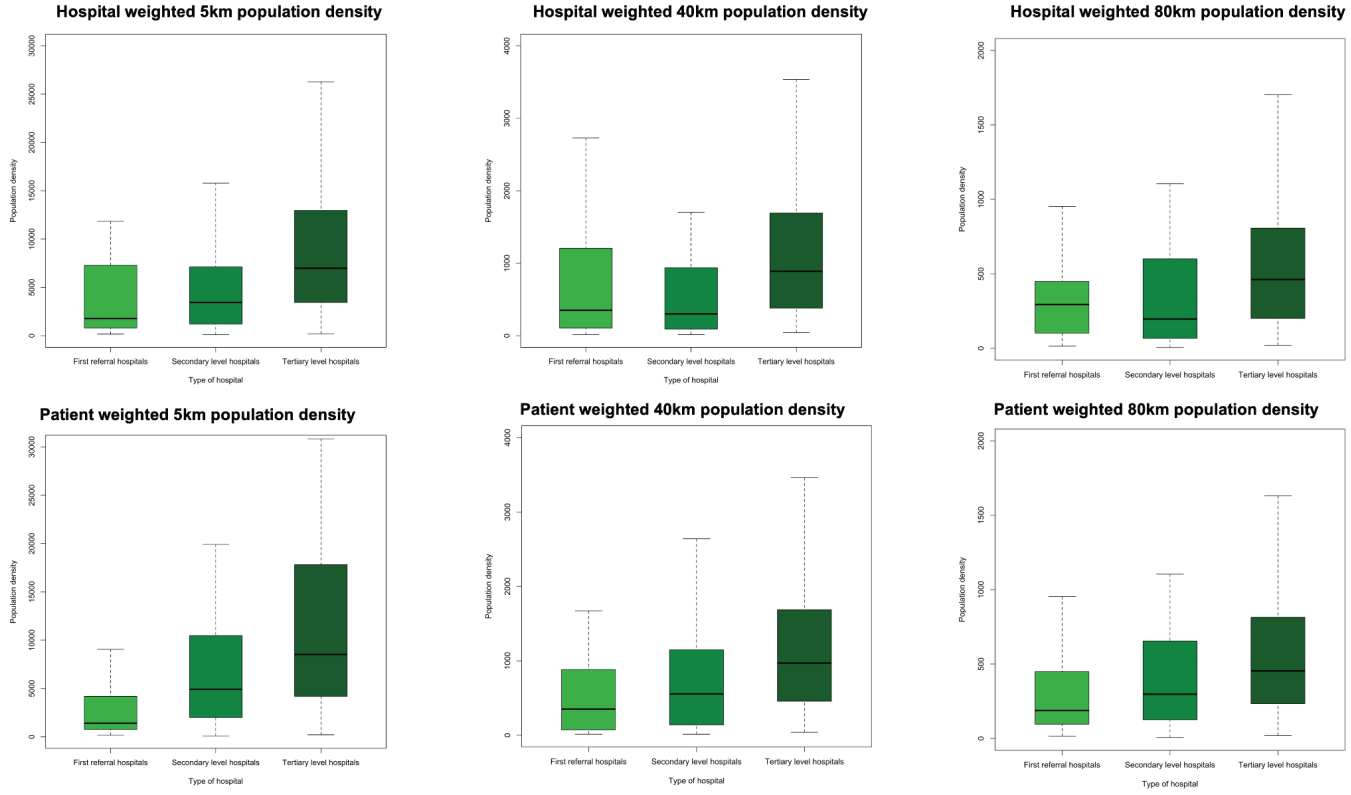
These maps can be found as interactive versions online following these links: https://www.datawrapper.de/_/n6uid/?v=3, https://www.datawrapper.de/_/c2eZ4/ and https://www.datawrapper.de/_/k0kz6/.

Results

Overall, there were 328 hospitals located in low and middle income countries, from where location data was found for 326. From these, 38 hospitals were First Referral Hospitals, 84 hospitals were secondary level hospitals and 204 hospitals were tertiary level hospitals. The exact location of each hospital is shown in Figure 1.

The population density varied according to the hospital types and all had a skewed distribution. The 5 km density population median in first referral hospitals was 1,776 inhabitants per square kilometre, in secondary level hospitals it was 3,439 inhabitants per square kilometre and in tertiary level hospitals it was 6,979 inhabitants per square kilometre, as shown in figure 2. For the 40km distance, the variation was smaller. However, a difference between tertiary-level hospitals and the other two types was still present, with a median difference for secondary level hospitals of 566,26 and to first referral hospitals of 536,92. For the 80 km, the variation was even smaller, as shown in figure 2.

Figure 2: Hospital and patient weighted population density



When weighing the patients recruited from each hospital, the density population medians changed and showed a similar trend across all distances tested. The 5km population density median increased from FRHs to tertiary hospitals (1398, 4915 and 8521). The 40km population density median followed the same trend (351, 555 and 969). Finally, the 80km population density median also increased from FRHs to tertiary hospitals (188, 297 and 454).

Discussion

The main finding of this study was the increase in the population density from FRHs to tertiary hospitals. This was observed in all distances tested and a proportionate increase was shown when patients enrolled in the study were considered as a weighing factor. Interpreting this and the location of each hospital, tertiary hospitals were mostly located in city centres, which were likely surrounded by higher numbers of population.

This finding was consistent with previous literature, where FRHs were usually located in less populated areas. However, the methods reported were less time consuming and the platforms and softwares used were available for free to everyone. This allows it to be scaled up and used for other studies.

There were limitations inherent to this analysis. First, the GPS coordinates were extracted from Google maps and not from the “person to contact in the country”. Therefore, the GPS coordinates might not exactly match with the true GPS coordinates of the hospital. Second, the software used to extract the population around the hospital might not be as accurate in rural areas which is acknowledged in the website. Third, whenever the radius crossed the border of a different country, it was not possible to

exclude that population that was captured. Finally, the methods described were applied to an international cohort study of inguinal hernia patients. Therefore, there was an inherent selection bias of hospitals.

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