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National and subnational estimates of coverage and travel time to public health facilities and emergency obstetric care in Afghanistan: Modeling of spatial accessibility

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Abstract

In Afghanistan, the risk of maternal death is among the highest in the world, with wide variation across the country. One explanation may be wide geographic disparities in access and use of maternal health care services. This study describes the spatial distribution of public facilities

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Declaration of Interest statement

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providing maternal health care in Afghanistan, specifically emergency obstetric care (EmOC), and the differences in travel time estimates using different transportation modes from 2010 to 2015 at the national and subnational levels. We conducted mapping and spatial analyses to measure the proportion of pregnant women able to access any EmOC health facility within two hours by foot, animal, motor vehicle and a combination of transport modes. In 2015, adequate coverage of active public health facilities within two hours of travel time was 36.6% by foot and 71.2% by a combination of transport modes. We found an 8.3% and 63.2% increase in access to EmOC facilities within 2 hours of travel time by a combination of transport modes and by foot only, respectively, by 2015. Access to a combination of transportation options such as motor vehicles and animals may benefit pregnant women in reaching health facilities efficiently. Afghanistan made impressive gains in maternal healthcare access; despite these improvements, large disparities remain in geographic access by province and overall access to facilities is still poor.

Keywords

Access to healthcare; maternal healthcare; Afghanistan; spatial analysis; geographic disparities

1. Introduction

From 1990 to 2015, maternal deaths decreased by 29% globally. While this represents a significant improvement, there was still an estimated 275,288 maternal deaths in 2015 (Kassebaum *et al.*, 2016). Emergency obstetric and newborn care (EmONC) services that manage preventable and treatable complications during childbirth can reduce the risk of maternal and newborn mortality (Paxton *et al.*, 2005; Ameh *et al.*, 2012). EmONC facilities provide two tiers of services: Basic (BEmONC) facilities provide seven signal functions of obstetric care, while Comprehensive (CEmONC) facilities provide nine signal functions (World Health Organization (WHO), 2009a). In many low and middle-income countries (LMIC), the availability of, and capacity to deliver, quality EmONC services is low. The World Health Organization (WHO) defines adequate availability as a minimum of five EmONC facilities per 500,000 population at national and subnational levels, including one CEmONC facility with availability 24 hours a day, seven days a week over a three-month reporting period (World Health Organization (WHO), 2009b). Physical access to a facility can be estimated most easily by a straight-line distance between two points; however, spatial models that incorporate road networks, terrain, and transport modes provide more realistic estimates of travel time. The WHO indicator for EmONC services does not account for timely access defined by a woman's travel time rather than straight line distances (Kruk *et al.*, 2009; Tappis *et al.*, 2016; Ebener *et al.*, 2019). Poor geographic access to EmONC facilities contributes to delays in receiving life-saving care that can result in adverse maternal and newborn outcomes (Chen *et al.*, 2017; Schmitz *et al.*, 2019).

In Afghanistan, the risk of maternal death is among the highest in the world with an estimated 8,525 deaths in 2015 and a maternal mortality ratio of 789 deaths per 100,000 live births (Kassebaum *et al.*, 2016; Bartlett *et al.*, 2017). Following the removal of the Taliban regime in 2001, significant progress has been made to rebuild Afghanistan's health care system (Akseer *et al.*, 2016). Primary care services delivered are provided at three main

clinic levels: Sub Health Centers, Basic Health Centers, and Comprehensive Health Centers (Dalil *et al.*, 2014; Newbrander, Ickx, *et al.*, 2014).

Since 2002, the Afghanistan Ministry of Public Health (MoPH) prioritized improving maternal health outcomes as part of its national health strategy (MoPH [Afghanistan], 2005; Reproductive Health Taskforce (Women's and Reproductive Health Directorate) [Afghanistan MoPH], 2005). Between 2003 and 2015, coverage of maternal health care interventions increased for antenatal care (16% to 59%), skilled birth attendance (14% to 51%), and births in a health facility (13% to 48%) (Akseer *et al.*, 2016; MoPH [Afghanistan] and Central Statistics Organization (CSO) [Afghanistan], 2017). All Comprehensive Health Centers are expected to provide BEmOC and hospitals should provide CEmOC; however, only 68% of surveyed facilities performed all BEmOC signal functions and 56% of facilities performed all CEmOC signal functions in 2010 (Kim *et al.*, 2012). Because newborn resuscitation is minimally available in Afghanistan, we use EmOC to capture services other than the newborn care signal function likely offered and captured by the routine health information system (Atiqzai *et al.*, 2019).

Geographic disparities in maternal health care utilization and outcomes have been reported, particularly among the most rural and mountainous regions of the country (Kim *et al.*, 2012; Bartlett *et al.*, 2017). Distance and lack of transportation are often-cited barriers to accessing maternal health care (Newbrander, Natiq, *et al.*, 2014; Hirose *et al.*, 2015; Akseer *et al.*, 2016; Higgins-Steele *et al.*, 2018). There is a growing literature examining geographic accessibility to maternal health care services using straight line distances (Ebener *et al.*, 2015; Makanga *et al.*, 2016); however, straight line distances may misrepresent geographic accessibility, especially in rural and mountainous LMIC contexts present in parts of Afghanistan. For instance, a study in Ethiopia, which is characterized as mountainous with poor road networks, found that straight line distances and spatial access time measures were not comparable (Okwaraji *et al.*, 2012). Further, access to transportation is essential to decreasing travel time to EmOC services. To our knowledge, no previous study has conducted spatial modeling of travel times to improve our understanding of access to public health facilities and facilities providing EmOC services in Afghanistan. To the best of our knowledge, the different uses of transport modes and their influence on travel times to EmOC services has not been explored in Afghanistan, and is limited in LMIC settings. This is particularly true for modes such as animals (horse or donkey) or use of a combination of modes (walking and motor vehicle).

The aim of this study is to describe the spatial distribution of public health facilities providing maternal health care services, specifically public EmOC facilities. We assess the differences in travel time estimates using different transportation modes from 2010 to 2015 at the national and subnational levels, including spatial access trends and changes over the study period. Using a combination of spatial data and data from the Afghanistan Health Management Information System (HMIS) we conducted mapping and spatial analyses to measure the proportion of pregnant women able to access any EmOC facility and public clinic or hospital within two hours using multi-modes of transportation. Key maternal health services are currently underutilized and the health status of Afghan women remains among the poorest among all LMICs. Improving the health status of the most vulnerable

populations requires a better understanding of the access and use of health care and their changes over time. This study provides information to understand geographic disparities in access and to identify gaps in maternal health service coverage areas.

2. Data and Methods

2.1 Study Setting

Afghanistan is a predominantly rural, landlocked, mountainous country in South-Central Asia. It is divided into 34 provinces (Figure 1). Of a total population of 29.1 million people, 71.2% live in rural areas, 23.8% live in urban areas, and 5.0% are nomadic (CSO, 2018). Over half (54.5%) of the population lives below the national poverty line and 47.7% are younger than 15 years (CSO, 2018). The total fertility rate is 5.3 children per woman (MoPH [Afghanistan] and CSO [Afghanistan], 2017). In 2015, fewer than half (48%) of women gave birth in a health facility (MoPH [Afghanistan] and CSO [Afghanistan], 2017).

The Hindu Kush mountains divide Afghanistan into three distinct geographic areas: central highland, southern plateau, northern plains (Afghanistan Public Health Institute (APHI) *et al.*, 2011). The central highland has high mountains and deep valleys with extreme seasons and topography ranging from semi-desert to grass steppe; the southern plateau is mainly arid desert and high plateaus, with mild and dry climate; and, the northern plains have fertile high plains and several large mountainous regions (APHI *et al.*, 2011). As shown in Figure 2, the central highlands (i.e., Bamyan province), northern mountainous regions (i.e., Badakhshan province), and the southern desert areas (i.e., Nimroz province), are sparsely populated.

2.2 Data Sources

Spatial data—Spatial data were obtained from several publicly-available sources and the Afghanistan MoPH. We gathered data on settlements, provincial boundaries, road networks, water bodies, landcover, and health facilities from 2012–2013 Afghanistan Information Management Services (AIMS) through the Humanitarian Data Exchange (OCHA, 2019). The road network included main, secondary, and tertiary roads in 2012. Updated health facility coordinates were provided by the MoPH from 2015; 30 of the 1,904 health facilities' coordinates were in locations such as water bodies, rivers, or roads. These facilities' coordinates were edited to their nearest acceptable land area. Gridded population density data on pregnancies in 2010, 2013, and 2015 were obtained from WorldPop at a spatial resolution of 100m (WorldPop and Guttmacher Institute, 2018). The source of the digital elevation data was the US Geological Survey at a spatial resolution of 90m (USAID and USGS, 2019).

Health Management and Information System (HMIS) data—HMIS data were provided by the MoPH to identify all BPHS health facilities and hospitals, their activity level (fully or partially active) in 2010, 2013, and 2015, and whether the facilities reported providing EmOC services (by quarter in 2010 and semiannually in 2013 and 2015). We designated facilities as providing EmOC if they were reported as providing EmOC for the entire year. The full HMIS dataset had 1,904 unique health facilities; we excluded 189

facilities designated as other (such as, prison health centers or TB clinics) (n=73), mobile health team (n=66), or not active/no GPS coordinates (n=50). HMIS data on facility activity and EmOC status by year were merged with health facility coordinates in Stata 14 (StataCorp, 2015) and exported for use in ArcGIS 10.5.1 (ESRI, 2011).

2.3 Measures

We conducted mapping and spatial analyses to measure the proportion of pregnant women able to access any EmOC and public health facility within a given travel time (Ebener *et al.*, 2019). The two main variables of change in our spatial model are pregnant women population and number of public health facilities/EmOC designated facilities. We used a maximum travel time of two hours which is how the MoPH defines BPHS facility catchment areas (MoPH, 2010) and has been used in similar studies in other LMICs (Chen *et al.*, 2017; Ouma *et al.*, 2018). Travel times greater than two hours to emergency obstetric care are associated with maternal mortality due to delays in treatment of complications (Pirkle *et al.*, 2011) and the onset of untreated severe post-partum hemorrhage and death (Shakur *et al.*, 2017; Gayet-Ageron *et al.*, 2018). Definitions of measures used – spatial access, percent coverage, and percent change in coverage – are presented in Table 1.

2.4 Data Analysis

Modeling of travel time by transportation mode in GIS—We generated a merged land cover layer using a combination of landcover, elevation, road, rivers, and water body layers in AccessMod (version 5.0.7) (Ray and Ebener, 2008) to create a raster surface of travel time to all health facilities. The land cover layer was exported with raster grid cell sizes of 100m; all subsequent raster layers were aligned with this spatial resolution. The original land cover layer containing 21 land types and sub-types was simplified into six unique types (Chen *et al.*, 2017; Schmitz *et al.*, 2019): grass land, crop land, forest land, other land cover, barriers, and settlements, in addition to the three road classes. Separate raster travel time layers were then derived for each mode of transport (motor vehicle, donkey, and foot) with 100m² resolution where each cell contained an impedance value. Travel impedance was modeled from the central location of the village to the nearest public health facility by a given transport mode. We used ArcGIS to calculate the quickest routes between villages and their nearest public health facility or facility providing EmOC services based on predefined speed limits (detailed below) and ease of travel across the six specified land cover types.

Given the geographic diversity of Afghanistan, understanding access via multiple modes of transport is important given unpaved roads are not easily traversable by motor vehicle. Four travel scenarios were modeled: foot only, foot and animal, foot and motor vehicle, and a combination of foot, animal, and motor vehicle. These transport scenarios were selected based on the Afghanistan Health Survey which found that 31% of households accessed health services mainly by foot, 56% by motor vehicle, 3% by animal (horse/mule/donkey), and 10% by other means (The Royal Tropical Institute and Silk Route Training and Research Organization, 2016).

We estimated speeds for each transport mode from several sources. Walking speeds for pregnant women were taken from the AccessMod manual, a similar study in Tanzania (Chen *et al.*, 2017), and a study assessing the delays in traveling to an EmOC facility in Herat province, Afghanistan (Hirose *et al.*, 2015). Based on these previous studies, we estimated walking speeds of 1 km/hr on forest land, 1.7 km/hr on grass land and crop land, and 2.5 km/hr on all other land cover types and roads. The average walking speed of a donkey for all land cover types traversable by animal was estimated to be 6.4 km/hr (Thornton-O'Connell, 2019). Motor vehicle speeds used were as follows: 50km/hr on major roads, 40 km/hr on secondary roads, and 15 km/hr on local roads/dirt roads based on Afghanistan's 50 km/hr speed limit for urban areas (WHO, no date) and a prior study which provided estimates for speeds on secondary and local roads (Chen *et al.*, 2017). We assigned the travel speeds to each land cover type by each travel mode to estimate travel time surfaces to every health facility point.

We modeled accessibility areas by limiting the maximum travel time to any facility to two hours. This analysis was performed separately for all public health facilities and facilities providing EmOC in 2010, 2013, and 2015. Using zonal statistics, we obtained the percent coverage of pregnancy women within the modeled two-hour accessibility areas, by travel mode and a combination of all three modes. Additionally, we analyzed a scenario of changes in access using 2010 EmOC facilities on 2010 and 2015 population pregnancy data.

We present results as percentages for all transport modes at the national level. Maps are presented for travel by foot and by a combination of travel modes, as these illustrated the least (foot) and the most (combination of modes) efficient access. Bamyan province in the Central Highlands was selected as a provincial example to visualize variation in travel time. It is important to note that the province was selected as a visual example of the changes in travel time.

2.5 Ethical considerations

Permission to use all datasets for this secondary data analysis was granted by the MoPH in Kabul, Afghanistan. We received an exemption from the Institutional Review Board at the University of North Carolina at Chapel Hill to conduct this study (#16-3202).

3. Results

Table 2 shows the total number of active health facilities and full EmOC-designated facilities included in the analysis for each year. Table 3 presents country-level coverage of pregnant women by modes of transportation to fully active health facilities and EmOC facilities. We found that 34.4% of pregnant women could access active public health facilities within two hours by foot in 2010, 56.0% by motor vehicle, and 62.7% by donkey. A combination of the three transport modes achieves the greatest levels of access for pregnant women for each year. Coverage of active public health facilities did not increase between 2010 and 2015; however, the coverage of EmOC facilities when traveling by foot increased from 10.2% in 2010 to 28.3% in 2013 to 27.7% in 2015.

Figure 3 shows the change in access to an EmOC facility within two hours of travel time using a combination of transport modes. By 2015, denser networks of coverage areas are visible in all areas, especially in the eastern, central, and northern regions of the country. Although some of the most mountainous regions of the country are in the northern and central regions, where accessing facilities has greater challenges, improvements in access to EmOC facilities can be seen.

Although many areas remain further than two hours away by foot from an EmOC facility in Bamyān province (Figure 4), the availability of health facilities designated to provide these services has increased markedly. Areas more than 15 hours from an EmOC facility by foot have visibly reduced over this period. There is also provincial variation in the percent coverage of pregnant women within two hours of travel time by foot a combination of transport modes to the nearest public facility in 2010 and 2015 (Figure 5). Provinces with the highest percent coverage tend to cluster around Kabul (Central region) for both years for both types of transport modes. In 2010, provinces with the least access within two hours by foot were Nuristan in the East (2.7%) and Ghor and Badghis in the West (both 0.2%) to public facilities and EmOC facilities, respectively (Supplemental Table 1). Kabul (85.3%) and Parwan (Central) (37.6%) had the greatest access within two hours by foot to public facilities and EmOC facilities in 2010, respectively. By 2015, coverage increased to 4.3% in Nuristan and 2.4% in Ghor. While Kabul maintained high coverage by 2015, there was a decrease to 28.9% of pregnant women with access to EmOC facilities in Parwan. Provinces with the largest urban centers have the highest coverage of pregnancies within two hours by any transport mode to both public facilities and EmOC facilities in 2015. These provinces are: Kabul, Nangarhar (East), and Balkh (North). The percentage change between the two years at the provincial level is also shown in Figure 3. Although Parwan province had overall high coverage, from 2010 to 2015, it had a negative percentage change for both transport modes. Provinces with the highest positive changes in coverage by foot were Bamyān (Central Highlands), Samangan (North), Nuristan, Zabul (South), and Uruzgan (South).

Figure 6 shows the areas of the country where changes in access to EmOC facilities within two hours of travel time occurred between 2010 and 2015. These results show that there was an increase in access to EmOC facilities for pregnant women, especially in the central and northern parts of the country. Had the number of EmOC facilities remained at the 2010 level, these pregnant women would not have had access to EmOC services. Overall, there was a 63.2% increase in access to EmOC facilities by foot within a two-hour travel time during this period (Supplemental Table 2). Kunduz province in the North had the greatest decline in access to EmOC facilities by foot and by a combination of transport modes during this period.

4. Discussion

This study provides a more comprehensive understanding of spatial access to public health facilities and those providing EmOC services in Afghanistan. Despite policies to increase services for pregnant women, large gaps in access remain. In 2015, adequate coverage of active public health facilities was 36.6% by foot and 71.2% by a combination of transport modes. Similar to other studies, we found that modes of transport influence access to needed

health care, particularly in rural areas with diverse terrain (dos Anjos Luis and Cabral, 2016; Chen *et al.*, 2017). We specifically discuss our estimation of spatial accessibility using improved methods, how access has changed over time, and how modes of transport influence access to needed maternal healthcare.

Spatial accessibility modeling is an innovative tool that can be used to inform policies that improve population health. Spatial accessibility estimates in this study are lower than those reported in the Afghanistan Living Conditions Survey (93% of the population self-reported within two hours of walking in 2015) (Central Statistics Organization (CSO) [Afghanistan], 2008; Central Statistics Organization (CSO), 2018) or a study by Das *et al.* (57% of the population self-reported within one hour of walking in 2014) (Das *et al.*, 2018). Differences in estimates may be explained by our including only active public facilities, using two hours travel time (instead of one), and modeling pregnancy women not the entire population. More importantly, we conducted spatial analysis rather than relying on self-reported travel times from a sample of patients. We believe spatial analysis provides objective, replicable measures, and are an improvement over previously reported estimates of coverage and access.

Our findings show an 8.3% and 63% increase in access to EmOC facilities by a combination of transport modes and by foot only, respectively, by 2015. The large increase in access by foot suggests an expansion of EmOC services closer to communities, aligning with the government's prioritization of decreasing maternal mortality. Yet, declines in access were identified in some provinces, particularly in Kunduz. Reports have documented the impact of conflict on the delivery of health services, which may have been the case in Kunduz with increased violence and insurgency attacks, which culminated in 2015 when the Taliban took over the capital city for nearly 2 weeks (Haar *et al.*, 2014; Carthaigh *et al.*, 2015; Human Rights Watch, 2015). The escalating violence has resulted in increased attacks on health facilities and health workers, forcing health facilities to close temporarily (Carthaigh *et al.*, 2015; WHO, 2017). This study tells a consistent story about utilization and availability of maternal health services with the 2015 Afghanistan Demographic and Health Survey. Institutional deliveries by province were the lowest in Badghis and Nuristan; this study showed that these two provinces had the lowest coverage of EmOC facilities by all transport modes (MoPH [Afghanistan] and CSO [Afghanistan], 2017).

The additional time points in our study further shows the inconsistency in access to active public health facilities and EmOC facilities as service activity levels are designated quarterly or semi-annually via the HMIS. Our results may overestimate access to public health facilities and EmOC facilities since we were unable to verify the availability and quality of maternal health services, specifically EmOC signal functions provided through a facility assessment. A previous assessment of CEmOC facilities found that they did not provide the full range of signal functions (Kim *et al.*, 2012). BPHS implementing organizations and the MoPH should ensure that facilities have the appropriate capacity to perform all signal functions as required.

Our findings suggest that access to a combination of transportation modes may benefit pregnant women in reaching health facilities. Afghanistan's diverse topography and

mountainous geography may make a standard-sized motorized vehicle inefficient or ineffective at times. Access to smaller mechanized vehicles such as a motor bicycle or to an animal may decrease travel time in some areas. Strategies to provide alternative transport options to pregnant women to access facilities (e.g., protected seats on donkeys, detachable patient carriages for bicycles or motor bicycles) are being piloted (Blua, 2013; Saving Lives at Birth: a grand challenge for development, 2014). Research is needed to understand whether these modes of transport are acceptable to women and effective in not only bringing women to health facilities, but also for referring them to higher levels of care if needed.

This study has several limitations. The road network data was only available for 2012 and does not account for improvements in infrastructure during the study period. In addition, the spatial model does not account for women's facility preference and assumes that women will seek care at their nearest facility with EmOC (Keyes *et al.*, 2019). Data on travel speeds by each mode were based on other studies due to the lack of country-specific data, which may result in under- or over-estimation of travel speeds. GIS coordinates were unavailable for facilities affected by conflict; additionally, annual severe rainfall, flooding, and snow were not captured in our estimates of travel time and spatial access (UN Office for the Coordination of Humanitarian Affairs (OCHA), 2012; iMMAP, 2016). A study in Mozambique that incorporated seasonal variation from precipitation and flooding was able to show the impact of severe weather on access to health facilities (Makanga *et al.*, 2017). These estimates could be improved by including seasonality and conflict in the spatial access models.

Linking spatial, HMIS and EmOC data provides decision-makers with a powerful tool for monitoring and planning as they seek to strengthen the health care system in Afghanistan as it has in other countries. In Bangladesh, spatial data and maps identify clusters of underserved areas in maternal and child health care, advocate for reallocation of resources to address service gaps, and monitor progress (Robin *et al.*, 2019). Spatial data has also been used to analyze the efficiency and equity of travel time to hospitals in four Sub-Saharan Africa countries. This study showed that the spatial distribution of hospitals in these countries is efficient but tends to be inequitable (Wong *et al.*, 2019). Areas for placement of new hospitals or upgrading lower level facilities can be identified by prioritizing both spatial efficiency and equity using GIS data.

Spatial accessibility is often defined as access to a health facility, and often does not include the availability and quality of specific services. However, care seeking patterns differ for maternity care compared with outpatient care needs or child health services, likely due to perceived benefit and/or quality and availability of EmOC services. HMIS data used to identify EmOC facilities could not verify whether all signal functions were actually performed. The HMIS variable used was self-reported by the facility management as either providing basic EmOC or not during the reporting period, and could not be triangulated in the HMIS due to the lack of indicators captured on the specific signal functions. No facility assessment was conducted based on a chart review or data of whether the requisite treatments and procedures were performed. Linking spatial data to routine information systems and other facility or household survey data can provide more detailed accessibility information by service availability, quality, and care seeking patterns for specific service

areas. A better understanding of the effect of travel times to facilities and EmOC services on maternal health service use is needed. Further research is also needed to assess referral times from BPHS clinics to EPHS hospitals, health facility capacity to perform all EmOC signal functions, and care seeking patterns on when and where women are seeking care.

Spatial accessibility modeling is a unique tool for decisionmakers to understand geographic disparities in access and identify gaps in intervention coverage areas. This analysis shows that Afghanistan made impressive gains in access to public health facilities and EmOC facilities. However, despite these improvements, large disparities remain in geographic access by province and overall access to health facilities is still poor.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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REFERENCES

- Afghanistan Public Health Institute et al. (2011) Afghanistan Mortality Survey 2010.
- Akseer N et al. (2016) 'Coverage and inequalities in maternal and child health interventions in Afghanistan', BMC Public Health. BMC Public Health, 16(Suppl 2). doi: 10.1186/s12889-016-3406-1.
- Ameh C et al. (2012) 'Status of Emergency Obstetric Care in Six Developing Countries Five Years before the MDG Targets for Maternal and Newborn Health', PLoS ONE, 7(12), pp. 9–15. doi: 10.1371/journal.pone.0049938.
- dos Anjos Luis A and Cabral P (2016) 'Geographic accessibility to primary healthcare centers in Mozambique', International Journal for Equity in Health. International Journal for Equity in Health, 15(1), p. 173. doi: 10.1186/s12939-016-0455-0. [PubMed: 27756374]
- Atiqzai F et al. (2019) 'Quality of essential newborn care and neonatal resuscitation at health facilities in Afghanistan : a cross-sectional assessment', pp. 1–12. doi: 10.1136/bmjopen-2019-030496.
- Bartlett L et al. (2017) 'Progress and inequities in maternal mortality in Afghanistan (RAMOS-II): a retrospective observational study', The Lancet Global Health, 5(5), pp. e545–e555. doi: 10.1016/S2214-109X(17)30139-0. [PubMed: 28395847]
- Blua A (2013) A Donkey Ambulance for Women in Labor in Afghanistan, The Atlantic Available at: <https://www.theatlantic.com/international/archive/2013/09/a-donkey-ambulance-for-women-in-labor-in-afghanistan/280108/> (Accessed: 26 August 2019).
- Carthaigh NN et al. (2015) 'Patients struggle to access effective health care due to ongoing violence, distance, costs and health service performance in Afghanistan', International Health, 7(3), pp. 169–175. doi: 10.1093/inthealth/ihu086. [PubMed: 25492948]
- Central Statistics Organization (CSO) (2018) Afghanistan Living Conditions Survey 2016–17. Kabul.
- Central Statistics Organization (CSO) [Afghanistan] (2008) National Risk and Vulnerability Assessment 2007/8. Kabul.

- Chen YN et al. (2017) 'Geographic Access Modeling of Emergency Obstetric and Neonatal Care in Kigoma Region, Tanzania: Transportation Schemes and Programmatic Implications', *Global Health: Science and Practice*, 5(3), pp. 430–445. doi: 10.9745/ghsp-d-17-00110.
- Dalil S et al. (2014) 'Aid effectiveness in rebuilding the Afghan health system: a reflection.', *Global public health*, 9 Suppl 1(September 2015), pp. S124–36. doi: 10.1080/17441692.2014.918162. [PubMed: 24922192]
- Das JK et al. (2018) 'Scaling up primary health services for improving reproductive, maternal, and child health: A multisectoral collaboration in the conflict setting of Afghanistan', *BMJ (Online)*, 363, pp. 1–9. doi: 10.1136/bmj.k4986.
- Ebener S et al. (2015) 'The geography of maternal and newborn health: the state of the art', *International Journal of Health Geographics*. ???, 14(1), p. 19. doi: 10.1186/s12942-015-0012-x. [PubMed: 26014352]
- Ebener S et al. (2019) 'Proposing standardised geographical indicators of physical access to emergency obstetric and newborn care in low-income and middle-income countries', *BMJ Global Health*, 4(Suppl 5), p. e000778. doi: 10.1136/bmjgh-2018-000778.
- ESRI (2011) 'ArcGIS Desktop: Release 10.5.1'. Redlands, CA: Environmental Systems Research Institute.
- Gayet-Ageron A et al. (2018) 'Effect of treatment delay on the effectiveness and safety of antifibrinolytics in acute severe haemorrhage: a meta-analysis of individual patient-level data from 40 138 bleeding patients', *The Lancet*, 391(10116), pp. 125–132. doi: 10.1016/S0140-6736(17)32455-8.
- Haar RJ et al. (2014) 'Measurement of attacks and interferences with health care in conflict: validation of an incident reporting tool for attacks on and interferences with health care in eastern Burma.', *Conflict and health*, 8(1), p. 23. doi: 10.1186/1752-1505-8-23. [PubMed: 25400693]
- Higgins-Steele A et al. (2018) 'Barriers associated with care-seeking for institutional delivery among rural women in three provinces in Afghanistan', *BMC Pregnancy and Childbirth*. *BMC Pregnancy and Childbirth*, 18(1), pp. 1–9. doi: 10.1186/s12884-018-1890-2. [PubMed: 29291732]
- Hirose A et al. (2015) 'Determinants of delays in travelling to an emergency obstetric care facility in Herat, Afghanistan: An analysis of cross-sectional survey data and spatial modelling', *BMC Pregnancy and Childbirth*, 15(1). doi: 10.1186/s12884-015-0435-1.
- Human Rights Watch (2015) Afghanistan: events of 2015. Available at: <https://www.hrw.org/world-report/2016/country-chapters/afghanistan> (Accessed: 4 August 2019).
- iMMAP (2016) Afghanistan Spatial Data Center. Available at: http://asdc.immap.org/documents/?category__identifier__in=fl-01&category__identifier__in=fl-02&order_by=-date&limit=20&offset=0 (Accessed: 8 September 2019).
- Kassebaum NJ et al. (2016) 'Global, regional, and national levels of maternal mortality, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015', *The Lancet*, 388(10053), pp. 1775–1812. doi: 10.1016/S0140-6736(16)31470-2.
- Keyes EB et al. (2019) 'Geographic access to emergency obstetric services: A model incorporating patient bypassing using data from Mozambique', *BMJ Global Health*, 4, pp. 1–10. doi: 10.1136/bmjgh-2018-000772.
- Kim YM et al. (2012) 'Availability and quality of emergency obstetric and neonatal care services in Afghanistan', *International Journal of Gynecology and Obstetrics*. *International Federation of Gynecology and Obstetrics*, 116(3), pp. 192–196. doi: 10.1016/j.ijgo.2011.10.017. [PubMed: 22196990]
- Kruk ME et al. (2009) 'Bypassing primary care facilities for childbirth: A population-based study in rural Tanzania', *Health Policy and Planning*, 24(4), pp. 279–288. doi: 10.1093/heapol/czp011. [PubMed: 19304785]
- Makanga PT et al. (2016) 'A scoping review of geographic information systems in maternal health', *International Journal of Gynecology and Obstetrics*. *International Federation of Gynecology and Obstetrics*, 134(1), pp. 13–17. doi: 10.1016/j.ijgo.2015.11.022.
- Makanga PT et al. (2017) 'Seasonal variation in geographical access to maternal health services in regions of southern Mozambique.', *International journal of health geographics*. *BioMed Central*, 16(1), p. 1. doi: 10.1186/s12942-016-0074-4.

- Ministry of Public Health [Afghanistan] (2005) National Health Policy and National Health Strategy 2005.
- Ministry of Public Health [Afghanistan] and Central Statistics Organization [Afghanistan] (2017) Afghanistan Demographic and Health Survey 2015. Available at: <https://dhsprogram.com/pubs/pdf/FR323/FR323.pdf>.
- MoPH (2010) A Basic Package of Health Services 2010/1389. Kabul.
- Nesbitt RC et al. (2014) 'Methods to measure potential spatial access to delivery care in low- and middle-income countries: a case study in rural Ghana', *Int J Health Geogr*, 13, p. 25. doi: 10.1186/1476-072X-13-25. [PubMed: 24964931]
- Newbrander W, Ickx P, et al. (2014) 'Afghanistan's Basic Package of Health Services: Its development and effects on rebuilding the health system', *Global public health*, (6), pp. 1–23. doi: 10.1080/17441692.2014.916735.
- Newbrander W, Natiq K, et al. (2014) 'Barriers to appropriate care for mothers and infants during the perinatal period in rural Afghanistan: A qualitative assessment', *Global public health*, 9 Suppl 1(00), pp. S93–S109. doi: 10.1080/17441692.2013.827735. [PubMed: 24003851]
- OCHA (2019) The Humanitarian Data Exchange v1.32.2. Available at: https://data.humdata.org/search?q=afghanistan&ext_search_source=main-nav&page=1 (Accessed: 28 July 2019).
- Okwaraji YB et al. (2012) 'Effect of Geographical Access to Health Facilities on Child Mortality in Rural Ethiopia : A Community Based Cross Sectional Study', 7(3), pp. 1–8. doi: 10.1371/journal.pone.0033564.
- Ouma PO et al. (2018) 'Access to emergency hospital care provided by the public sector in sub-Saharan Africa in 2015: a geocoded inventory and spatial analysis', *The Lancet Global Health*. The Author(s). Published by Elsevier Ltd This is an Open Access article under the CC BY 4.0 license, 6(3), pp. e342–e350. doi: 10.1016/S2214-109X(17)30488-6. [PubMed: 29396220]
- Paxton A et al. (2005) 'The evidence for emergency obstetric care', *International Journal of Gynecology and Obstetrics*, 88(2), pp. 181–193. doi: 10.1016/j.ijgo.2004.11.026. [PubMed: 15694106]
- Pirkle CML et al. (2011) 'Emergency obstetrical complications in a rural african setting (kayes, mali): The link between travel time and in-hospital maternal mortality', *Maternal and Child Health Journal*, 15(7), pp. 1081–1087. doi: 10.1007/s10995-010-0655-y. [PubMed: 20697934]
- Ray N and Ebener S (2008) 'AccessMod 3.0: Computing geographic coverage and accessibility to health care services using anisotropic movement of patients', *International Journal of Health Geographics*, 7, pp. 1–17. doi: 10.1186/1476-072X-7-63. [PubMed: 18190678]
- Reproductive Health Taskforce (Women's and Reproductive Health Directorate) [Afghanistan MoPH] (2005) National Reproductive Health Strategy for Afghanistan, Reproductive Health.
- Robin TA et al. (2019) 'Using spatial analysis and GIS to improve planning and resource allocation in a rural district of Bangladesh', *BMJ Global Health*, 4, pp. 1–9. doi: 10.1136/bmjgh-2018-000832.
- Saving Lives at Birth: a grand challenge for development (2014) Mareezbar (Patient-carriage) - a versatile all-terrain carriage for transporting maternal cases to health facilities. Available at: <https://savinglivesatbirth.net/summaries/317> (Accessed: 26 August 2019).
- Schmitz MM et al. (2019) 'Did Saving Mothers, Giving Life Expand Timely Access to Lifesaving Care in Uganda? A Spatial District-Level Analysis of Travel Time to Emergency Obstetric and Newborn Care', *Global Health: Science and Practice*, 7(Supplement 1), pp. S151–S167. doi: 10.9745/ghsp-d-18-00366.
- Shakur H et al. (2017) 'Effect of early tranexamic acid administration on mortality, hysterectomy, and other morbidities in women with post-partum haemorrhage (WOMAN): an international, randomised, double-blind, placebo-controlled trial', *The Lancet*, 389(10084), pp. 2105–2116. doi: 10.1016/S0140-6736(17)30638-4.
- StataCorp (2015) 'Stata Statistical Software: Release 14'. College Station, TX: StataCorp LP.
- Tappis H et al. (2016) 'Bypassing Primary Care Facilities for Childbirth: Findings from a Multilevel Analysis of Skilled Birth Attendance Determinants in Afghanistan', *Journal of Midwifery & Women's Health*, p. n/a–n/a. doi: 10.1111/jmwh.12359.

- The Royal Tropical Institute and Silk Route Training and Research Organization (2016) Afghanistan Health Survey 2015: FINAL REPORT. Available at: <https://dhsprogram.com/pubs/pdf/FR323/FR323.pdf>.
- Thornton-O'Connell J (2019) Average Speed of Donkeys. Available at: <https://animals.mom.me/average-speed-donkeys-7802.html> (Accessed: 30 July 2019).
- UN Office for the Coordination of Humanitarian Affairs (OCHA) (2012) Afghanistan: Avalanches severely hamper aid delivery. Available at: <https://www.unocha.org/story/afghanistan-avalanches-severely-hamper-aid-delivery> (Accessed: 8 September 2019).
- USAID and USGS (2019) USGS Projects in Afghanistan. Available at: <https://afghanistan.cr.usgs.gov/geospatial-reference-datasets> (Accessed: 28 July 2019).
- Wong KLM et al. (2019) 'Current realities versus theoretical optima: an approach quantifying efficiency and socio-spatial equity of travel time to hospitals in low- and middle-income countries', *BMJ Glob Health*, 4(e001552), pp. 1–10. doi: 10.1136/bmjgh-2019-001552.
- World Health Organization (2017) Attacks on health care on the rise in Afghanistan. Available at: <http://www.emro.who.int/afg/afghanistan-news/attacks-on-healthcare-on-the-rise-in-afghanistan.html> (Accessed: 4 August 2019).
- World Health Organization (WHO) (2009a) Monitoring emergency obstetric care: a handbook. Edited by World Health Organization (WHO). World Health Organization (WHO).
- World Health Organization (WHO) (2009b) 'Monitoring Emergency Obstetric Care', p. vol.30.
- World Health Organization (WHO) (no date) Afghanistan: country profile, road safety status. Available at: https://www.who.int/violence_injury_prevention/road_safety_status/country_profiles/afghanistan.pdf.
- WorldPop and Gutmacher Institute (2018) Afghanistan 1km Pregnancies, Version 2.0, 2015 estimates of numbers of pregnancies per grid square. doi: 10.5258/SOTON/WP00591.

Highlights:

- Despite policies to increase services for pregnant women, geographic disparities remain.
- Increased access to emergency obstetric care suggest an expansion of services closer to communities.
- A combination of transportation modes may benefit pregnant women in reaching health facilities.

Figure 1.
Map of Afghanistan with 34 provinces

Figure 2.
Distribution of population in Afghanistan, 2010*

*Due to limited visible differences in the population distribution over the study period, we present data from 2010 only

Figure 3.
Access to an EmOC facility within two hours of travel time using a combination of transport modes, 2010–2015

Figure 4.
Travel time (in hours) by foot to an EmOC facility in Bamyan province, 2010–2015

Panel A. Percent coverage of pregnant women with access to public health facilities within 2 hours of travel time using a combination of transport modes in 2010, 2015, and the percentage change

Panel B. Percent coverage of pregnant women with access to public health facilities within 2 hours of travel time by foot in 2010, 2015, and the percentage change

Figure 5.

Percent coverage and percentage change in pregnancies within 2 hours of travel time to the nearest public health facility by foot and using a combination of transport modes, 2010–2015

Figure 6.
Changes in access to EmOC facilities for 2015 estimates of the number of pregnant women using a combination of transport modes from 2010 to 2015

Table 1

Definition of measures

Spatial terms used	Definition
Spatial access	Ability of pregnant woman to access any public health facility or EmOC facility within two hours of travel time.
Percent coverage	Percent of pregnant woman able to access any public health facility or EmOC facility within two hours of travel time.
Percent change in coverage	The difference between 2015 and 2010 in the percent of pregnant women able to access any public health facility or EmOC facility within two hours of travel time over the 2010 percent coverage. A positive change is an increase and a negative change is a decrease in coverage.

Table 2

Total number of health facilities

	2010	2013	2015
Fully active public health facilities	1,512	1,618	1,715
Public health facilities reporting full EmOC availability	501	926	1,222

Table 3

Country-level coverage of pregnancies by transport mode, 2010–2015

% of pregnancies within 2 hrs. of travel time by:	Active public health facilities (%)			Facilities reporting EmOC availability (%)		
	2010	2013	2015	2010	2013	2015
Combination of transport modes	69.4	70.1	71.2	62.5	61.0	66.3
Foot	34.4	35.4	36.6	10.2	28.3	27.7
Motor vehicle	56.0	56.5	57.5	47.2	51.9	54.4
Donkey	62.7	63.5	65.0	28.6	51.4	57.5