

Re-evaluating the merits of decentralization as a core strategy for effective delivery of drug-resistant tuberculosis care in Pakistan

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Abstract

Decentralized, person-centred models of care delivery for drug-resistant tuberculosis (DR-TB) continue to be under-resourced in high-burden TB countries. The implementation of such models—made increasingly urgent by the COVID-19 pandemic—are key to addressing gaps in DR-TB care. We abstracted data of rifampicin-resistant (RR)/multidrug-resistant tuberculosis (MDR-TB) patients initiated on treatment at 11 facilities between 2010 and 2017 in Sindh and Balochistan provinces of Pakistan. We analysed trends in treatment outcomes relating to programme expansion to peri-urban and rural areas and estimated driving distance from patient residence to treatment facility. Among the 5586 RR/MDR-TB patients in the analysis, overall treatment success decreased from 82% to 66% between 2010 and 2017, as the programme expanded. The adjusted risk ratio for unfavourable outcomes was 1.013 (95% confidence interval 1.005–1.021) for every 20 km of driving distance. Our analysis suggests that expanding DR-TB care to centralized hubs added to increased unfavourable outcomes for people accessing care in peri-urban and rural districts. We propose that as enrolments increase, expanding DR-TB services close to or within affected communities is essential.

Keywords: Tuberculosis, decentralization, community, health outcomes, lung disease, developing countries, geographical information systems, infectious diseases

Introduction

For over two decades, the spread of drug-resistant strains has threatened global efforts in tuberculosis (TB) control. Inadequate real-time surveillance, limited deployment of x-ray based screening and rapid molecular confirmatory testing and ineffective referral pathways to detect, treat and manage patients have fuelled the drug-resistant tuberculosis (DR-TB) epidemic (Cox *et al.*, 2019). This has resulted in a growing access gap impacting the diagnosis and treatment of rifampicin-resistant (RR) and multidrug-resistant tuberculosis (MDR-TB). Of an estimated 465 000 RR/MDR-TB cases worldwide, only 48% were diagnosed, and 38%

started treatment in 2019 (World Health Organization, 2020).

Decentralized, person-centred models of care delivery—where care is provided in the communities where people affected by TB disease and infection live and work—have demonstrated that access barriers to DR-TB care can be ameliorated to address the DR-TB epidemic (Daru *et al.*, 2018; Evans *et al.*, 2018; Zawedde-Muyanja *et al.*, 2018). Such models have demonstrated increased value compared with those based on in-patient care (Van Rensburg *et al.*, 2019; Lyakurwa *et al.*, 2021). However, despite the World Health Organization's (WHO) endorsement of a decentralized model

Key messages

1. Despite evidence and policy in favour of decentralized, person-centred models of care, low- and middle-income countries continue to face major access barriers in the management of DR-TB care delivery from diagnosis to end of treatment.
2. We share our experience in the scale-up of routine DR-TB care at 11 facilities from 2010 to 2017 across two major provinces of Pakistan and its impact on treatment outcomes.
3. Expanding DR-TB services at a rapid rate may appear desirable; however, if not paired with a concurrent rise in high-quality community-based care close to where patients live or work, it may not improve the quality of clinical care and treatment outcomes.
4. Our study highlights the urgency of providing care close to patients' homes. This is especially pertinent in the era of COVID-19 pandemic, where intermittent lockdowns create further barriers in accessing healthcare for vulnerable communities suffering from DR-TB.

of care delivery for DR-TB in 2011, several challenges continue to be faced by implementers, many of which are context-specific and require local solutions ([Vanleeuw et al., 2020](#); [Leavitt et al., 2021](#)).

In the last several years, important changes in the RR/MDR-TB treatment landscape have included the introduction of two new oral drugs, bedaquiline and delamanid, and the prioritization of all-oral regimens ([Khan et al., 2019](#); [World Health Organization, 2019](#); [Franke et al., 2021](#)). While these are all welcome improvements, access to these treatments and to appropriate monitoring remains a challenge. This is further compounded by facility-based DR-TB care, which is usually not proximate to patient residence; this impacts the overall quality of clinical care and ultimately treatment outcomes ([Mezwa et al., 2018](#)).

In resource-limited settings such as Pakistan, which are already struggling to combat endemic infectious diseases such as DR-TB, the COVID-19 pandemic has rendered the population even more vulnerable and exacerbated the challenges ([Lloyd-Sherlock et al., 2020](#); [Mesa Vieira et al., 2020](#)).

In Pakistan, DR-TB services are primarily located at tertiary care facilities providing care to people from surrounding districts. Patients typically travel long distances for care, especially those who belong to peri-urban and rural areas. This can lead to suboptimal care resulting in pre-treatment loss to follow-up, overall poor treatment outcomes ([Jackson et al., 2017](#); [Ketema et al., 2019](#)) and negative public health impact due to unabated community transmission ([Van Cutsem et al., 2016](#)). A review of data on DR-TB treatment outcomes in Pakistan indicates a decrease of success rate from 70% (2011 cohort) to 64% (2017 cohort; [World Health Organization, 2014](#)). Although several demographic, biological and treatment-related factors may be responsible for this, we posit that the expansion of centralized DR-TB that does not adapt to community context and individuals' conditions largely accounts for this decline ([Abbas et al., 2021](#)).

In this manuscript, we aimed to assess the impact on treatment outcomes of scale-up of routine DR-TB services in two

major provinces of Pakistan: Sindh and Balochistan. We used distance to treatment site and its association with patient treatment outcomes to highlight the impact of centralized care on DR-TB patients' treatment outcomes.

Materials and methods

Setting

We present findings from a retrospective cohort of TB patients initiated on routine RR/MDR-TB treatment between 8 January 2010 and 30 December 2017 at 11 treatment sites in Pakistan. Of the 11 treatment sites, 9 were in Sindh province and 2 in Balochistan province. The majority of treatment sites were in the public sector; however, there were three private health facilities, all of which were in Sindh. Resource availability varied widely between sites ([Supplementary Table S1](#)). All sites were managed by the affiliated partner for DR-TB service provision. In Pakistan, routine second-line treatment is available through the national programme for TB control. This is primarily financed through the Global Fund to Fight AIDS, Tuberculosis and Malaria project, and patients are initiated on treatment based on national guidelines. The affiliated partner, a private-sector, not-for-profit organization that provides free-of-cost health services, along with its technical partner, the authors' institute, initiated DR-TB treatment through private donations in November 2007 in Karachi (Pakistan's most populous city, located in Sindh province). From 2010 onwards, the affiliated partner along with technical support from the authors' institute, supported the national programme for TB control to expand access to DR-TB services in Sindh and Balochistan provinces, providing free care at all 11 treatment facilities.

Patient monitoring and follow-up

At each site, patient monitoring was performed according to the national guidelines for DR-TB. Patients were initiated on treatment and evaluated during monthly outpatient visits for 18–24 months. Treatment adherence was monitored by treatment supporters (usually from patients' families). The programme provided monthly social support and travel allowance at a fixed rate of Pakistani rupees (PKR): 600 for each follow-up visit. To support patient monitoring, community activities such as monitoring of treatment supporters, contact tracing and tracking of patients who are lost to follow-up were supervised by treatment coordinators assigned to catchment areas or districts.

At the start of treatment, sputum smear microscopy, sputum culture and first- and second-line drug-susceptibility testing (DST) were performed according to guidelines. However, the provision and quality of follow-up services were highly dependent on the availability of resources at each site. For example, while smear and culture testing were routinely performed during follow-up, they were only available at select sites. Phenotypic DSTs were performed at the biosafety level 3 (BSL-3) laboratory at the affiliated partner's TB laboratory in Karachi, thus requiring specimen transport from most treatment facilities (for details see [Supplementary Table S1](#)). Clinical laboratory tests are part of the routine monitoring schedule but were subject to test availability at each site. Some sites had in-patient care facilities, while others had to

refer patients elsewhere for further management. One private-sector site with financing outside of the routine programme was able to support additional activities such as mental health care, contact tracing and adverse event monitoring. Post-treatment follow-up was required but not performed routinely across all sites.

Data collection

Routine programmatic data were collected for every patient enrolled using the national DR-TB paper forms at each site. Baseline demographics, clinical data and bacteriological results were entered into a Microsoft Excel file using a national programme-approved reporting template. Demographic and clinical data were abstracted retrospectively from

these files and included treatment facility, treatment initiation date, patient age, sex, home address, treatment history, site of disease (pulmonary vs extrapulmonary), chest x-ray, resistance profile, baseline bacteriology, phenotypic DST results and treatment outcome.

The patient addresses were cleaned and then geocoded using Google’s Geocoding Application Programming Interface (API; [Brokamp et al., 2018](#)). We used Google’s Directions API to compute the driving distance from the patient residence to their treatment facility ([Google Inc, 2021a,b](#)). For our analysis, we used the distance of the first-ranked recommended route by the Directions API. Approximately 87% of addresses were geocoded successfully on the first attempt. For the rest, a second round of data cleaning was performed, following which all addresses were successfully geocoded.

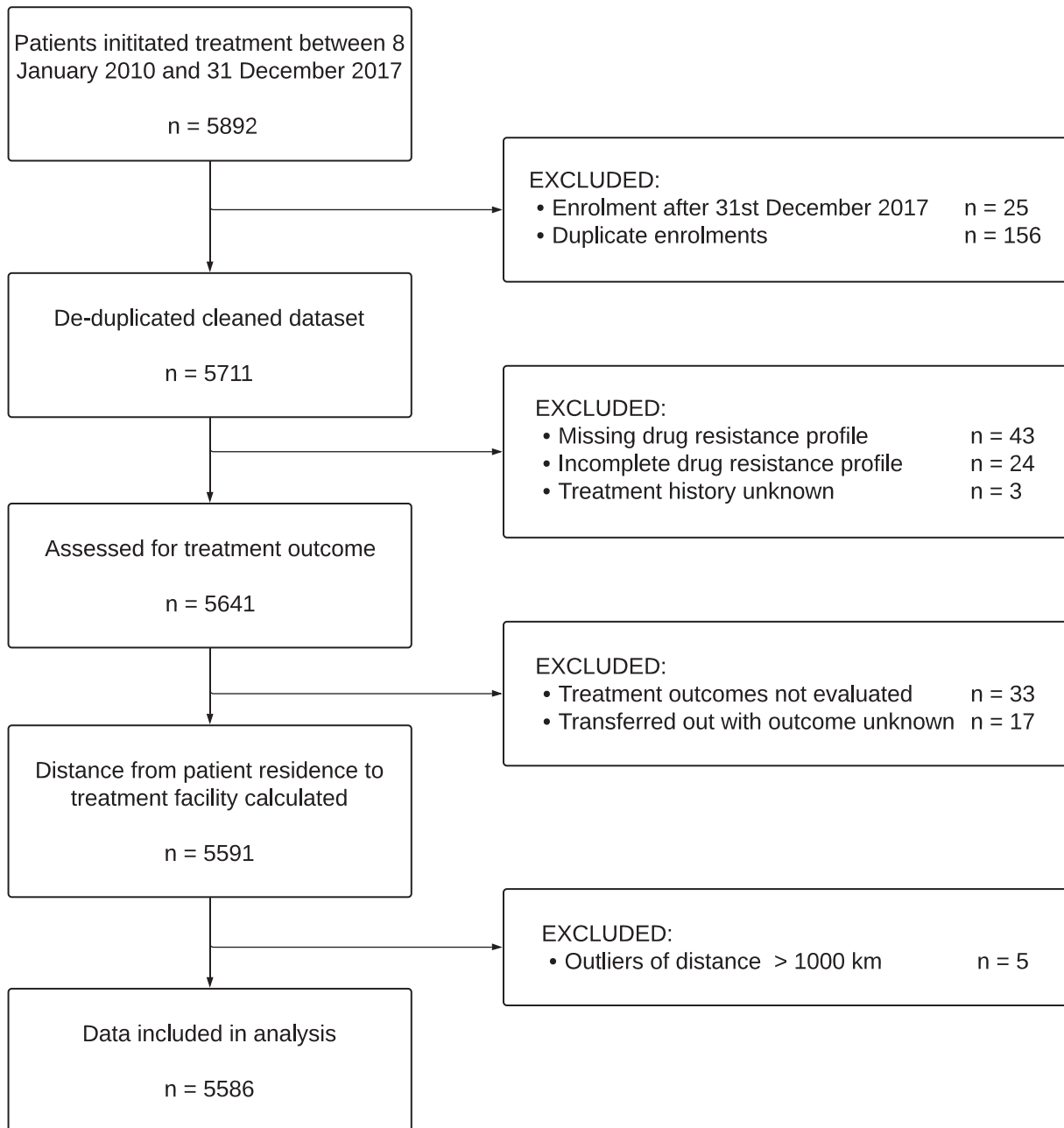


Figure 1. Study flowchart

Definition of treatment outcomes

We defined treatment outcomes based on the WHO definitions (World Health Organization, 2013) and created a binary variable ('favourable' vs 'unfavourable'). 'Unfavourable' outcomes included treatment failure, died and lost to follow-up. 'Favourable' treatment outcomes included treatment completion or cure. Patients with an outcome of 'transferred out' and 'not evaluated' were excluded (Figure 1).

Statistical methods

Our primary exposure of interest was driving distance to the treatment site from the patient's residence, and we estimated the association with an unfavourable treatment outcome using multivariable logistic regression to adjust for confounding (Model 1). Driving distance was included as a continuous variable (one unit for every 20 km travelled). The following potential confounders were included: age, sex, localization of disease, exposure to second-line regimen, fluoroquinolone (FQ) resistance, year of enrolment, advanced disease at diagnosis (defined as 3+ sputum smear-positivity and/or cavitation on chest x-ray) and treatment facility. Resistance profile was categorized based on baseline DST results as FQ-resistant or not. Patient residence type was defined as 'urban' if located in Karachi, whereas all other areas were categorized as 'peri-urban and rural'. We included treatment facility as a fixed effect in the model. A sensitivity analysis (Model 2), restricting inclusion to patients who were residents within 250 km of the treatment site, was undertaken to assess if the association with unfavourable outcomes was primarily driven by those living more than 250 km from their treatment facility. Complete-case analysis methods were used. For ease of interpretation, results of the logistic regression models are presented graphically as predicted probabilities of an unfavourable treatment outcome and risk ratios with 95% confidence intervals (CIs) using marginal standardization methods (Norton *et al.*, 2013). In brief, the predicted probability of an unfavourable treatment outcome is adjusted to a weighted average reflecting the confounder distribution in the total population (Muller and Maclehorse, 2014). Statistical analyses were carried out using Stata/SE 16 (College Station, TX: StataCorp LP).

Results

Participants

From 2010 to 2017, 5711 patients were initiated on RR/MDR-TB treatment at 11 facilities. Patients came from 172 tehsils (sub-districts) in 67 districts across Pakistan. We excluded 120 (2.1%) patients with incomplete or missing data pertaining to treatment outcomes, drug resistance or treatment history (Figure 1). We also excluded five patients for whom the calculated distance from residence to treatment facility was greater than 1000 km (Supplementary Figure S1).

A total of 5586 (97.7%) patients enrolled over 8 years across the 11 participating treatment facilities were included in the analysis (Table 1). The proportion of males and females was similar, and over half of the patients (3116; 55%) were below 35 years of age. One thousand six hundred and seventeen (29%) of the RR/MDR-TB patients were resistant to FQ at baseline. One thousand two hundred and fifty-six (22%) patients had advanced disease at the time of diagnosis,

and 447 (8%) patients had previously received a second-line treatment regimen. The majority of patients enrolled resided in the province of Sindh (92%) and most (88%) resided in peri-urban and rural areas (outside Karachi). The median estimated driving distance was 16 km (range: 0.5–707 km) for patients from urban areas, 59 km (range: 0.1–912 km) for those from peri-urban and rural areas and 46 km (range: 0.1–912 km) overall.

Program expansion

At the start of the programme in 2010–2011, 185 patients were enrolled at The Indus Hospital in Karachi. As the programme scaled up and additional treatment facilities were brought on board, enrolments increased rapidly from 730 in 2012–2013 to 2210 in 2014–2015 and 2460 in 2016–2017 (Figure 2). This expansion was supported by the increase in treatment coordinators from 3 during 2010–2011 to 15 in 2016–2017. However, the average number of patients supported by each treatment coordinator too increased from 64 to 250 during the same period (Supplementary Table S1).

This programme expansion was associated with a change in patient characteristics in terms of age, province of residence, peri-urban/rural (vs urban) residence type, resistance profile and treatment history (Table 1). With the opening of new treatment facilities, median distance to the treatment site for patients in surrounding districts declined over time (Figure 3). Median driving distance to a patient's treatment facility remained unchanged in urban areas. However, in peri-urban and rural areas, it decreased from a median of 164 km in 2010–2011 to 50 km in 2016–2017 (Table 1).

Treatment outcomes

Although most patients had favourable treatment outcomes (64% cured; 4% treatment completed), treatment success rates decreased over time from 82% in 2010 to around 66% from 2014 onwards (Figure 2). Patients lost to follow-up increased over time from 6% to a peak of 13% in 2014. Of note, patients residing in peri-urban and rural areas had an unadjusted 29% higher risk of unfavourable outcomes as compared to those living in Karachi (risk ratio 1.29, 95% CI 1.12–1.47). Compared to the Indus Hospital, which is located in an urban area of Karachi, all facilities located in peri-urban and rural areas had a higher unadjusted risk of an unfavourable outcome: ICD Kotri (risk ratio 1.20, 95% CI 1.06–1.36), Ghulam Muhammad Mahar Medical College, Sukkur (risk ratio 1.32, 95% CI 1.16–1.51), Fatima Jinnah Hospital, Quetta (risk ratio 1.31, 95% CI 1.10–1.55), Red Crescent Hospital, Hyderabad (risk ratio 1.58, 95% CI 1.21–2.06; Supplementary Table S2).

In the multivariate model of the association between distance to the treatment site and an unfavourable outcome, the adjusted risk ratio was 1.013 (95% CI 1.005–1.022) for every 20 km a patient needed to travel to reach their treatment facility, adjusted for age, sex, site of infection, exposure to second-line regimen, FQ resistance, year of enrolment, advanced disease at diagnosis (3+ smear-positivity and/or cavitation on chest x-ray) and treatment facility (Table 2). Typical travel distances (Figure 3) ranged between 0.1–911.5 km for people not living in the district centres (Table 1). The relationship between the predicted probability of an unfavourable treatment outcome and distance to the treatment facility is

Table 1. Baseline characteristics of MDR-TB patients by year of enrolment 2010–2017 (n = 5586)

	2010–2011		2012–2013		2014–2015		2016–2017		Total	
	n	%	n	%	n	%	n	%	n	%
Overall	185	3%	730	13%	2211	40%	2460	44%	5586	100%
Sex										
Males	90	49%	378	52%	1150	52%	1245	51%	2863	51%
Females	95	51%	352	48%	1061	48%	1215	49%	2723	49%
Age category ^a										
0–14 years	10	5%	25	3%	77	3%	83	3%	195	3%
15–24 years	67	36%	211	29%	615	28%	662	27%	1555	28%
25–34 years	41	22%	198	27%	551	25%	576	23%	1366	24%
35–44 years	32	17%	133	18%	398	18%	407	17%	970	17%
45–54 years	17	9%	86	12%	279	13%	367	15%	749	13%
55–64 years	15	8%	46	6%	185	8%	246	10%	492	9%
65+ years	3	2%	31	4%	103	5%	118	5%	255	5%
Province of residence										
Sindh	184	99%	647	89%	2042	92%	2270	92%	5143	92%
Balochistan	1	1%	83	11%	166	8%	185	8%	435	8%
Punjab	0	0%	0	0%	3	0%	5	0%	8	0%
Rural–urban residence										
Urban (Karachi)	55	30%	113	15%	205	9%	293	12%	666	12%
Peri-urban and rural (All other areas)	130	70%	617	85%	2006	91%	2167	88%	4920	88%
Driving distance to treatment site (km)										
Urban (Karachi)	23.8	(5.6–32.2)	17.4	(3.6–42.7)	17.1	(0.5–42.7)	14.5	(1.2–707.2)	16.3	(0.5–707.2)
Peri-urban and rural (all other areas)	164.2	(2.1–503.2)	89.2	(1.5–825.5)	61.6	(0.8–745.6)	50.2	(0.1–911.5)	59.2	(0.1–911.5)
Overall	30.5	(2.1–503.2)	58.0	(1.5–825.5)	52.4	(0.5–745.5)	37.9	(0.1–911.5)	46.4	(0.1–911.5)
Treatment facility ^b										
Indus Hospital (Karachi)	185	100%	275	38%	278	13%	291	12%	1029	18%
Institute of Chest Diseases (Kotri)	0	0%	273	37%	605	27%	525	21%	1403	25%
Ghulam Muhammad Mahar Medical College (Sukkur)	0	0%	80	11%	346	16%	370	15%	796	14%
Fatima Jinnah Hospital (Quetta)	0	0%	74	10%	142	6%	122	5%	338	6%
Civil Hospital (Mirpurkhas)	0	0%	4	1%	319	14%	298	12%	621	11%
People's Medical College Hospital (Nawabshah)	0	0%	0	0%	190	9%	300	12%	490	9%
Chandka Medical College Hospital (Larkana)	0	0%	11	2%	187	8%	230	9%	428	8%
Jinnah Postgraduate Medical Centre (Karachi)	0	0%	13	2%	144	7%	158	6%	315	6%
Red Crescent Hospital (Hyderabad)	0	0%	0	0%	0	0%	79	3%	79	1%
District Headquarters Hospital (Loralai)	0	0%	0	0%	0	0%	26	1%	26	0%
Delhi Medical Centre (Karachi)	0	0%	0	0%	0	0%	61	2%	61	1%

(continued)

Table 1. (Continued)

	2010–2011		2012–2013		2014–2015		2016–2017		Total	
	n	%	n	%	n	%	n	%	n	%
Site of TB infection										
Pulmonary ^c	177	96%	716	98%	2182	99%	2418	98%	5493	98%
Extrapulmonary	8	4%	14	2%	29	1%	42	2%	93	2%
Documented FQ resistance										
Yes	69	37%	265	36%	617	28%	665	27%	1617	29%
No	116	63%	465	64%	1593	72%	1795	73%	3969	71%
Previously treated with second-line drugs										
Yes	54	29%	69	9%	115	5%	209	8%	447	8%
No	131	71%	661	91%	2096	95%	2251	92%	5139	92%
Documented advanced disease										
Yes ^d	39	21%	213	29%	559	25%	445	18%	1256	22%
No	146	79%	517	71%	1652	75%	2015	82%	4330	78%
Treatment outcomes										
Cured	128	69%	501	69%	1389	63%	1543	63%	3561	64%
Treatment completed	16	9%	32	4%	98	4%	105	4%	251	4%
Treatment failed	11	6%	31	4%	119	5%	151	6%	312	6%
Died	23	12%	128	18%	354	16%	402	16%	907	16%
Lost to follow-up	7	4%	38	5%	251	11%	259	11%	555	10%

^aAge missing for four patients.

^bOrder of treatment facility follows the timing of when the site was opened.

^cIncludes 10 patients with both extrapulmonary and pulmonary infection.

^d3+ smear-positive, with or without cavitation on chest x-ray.

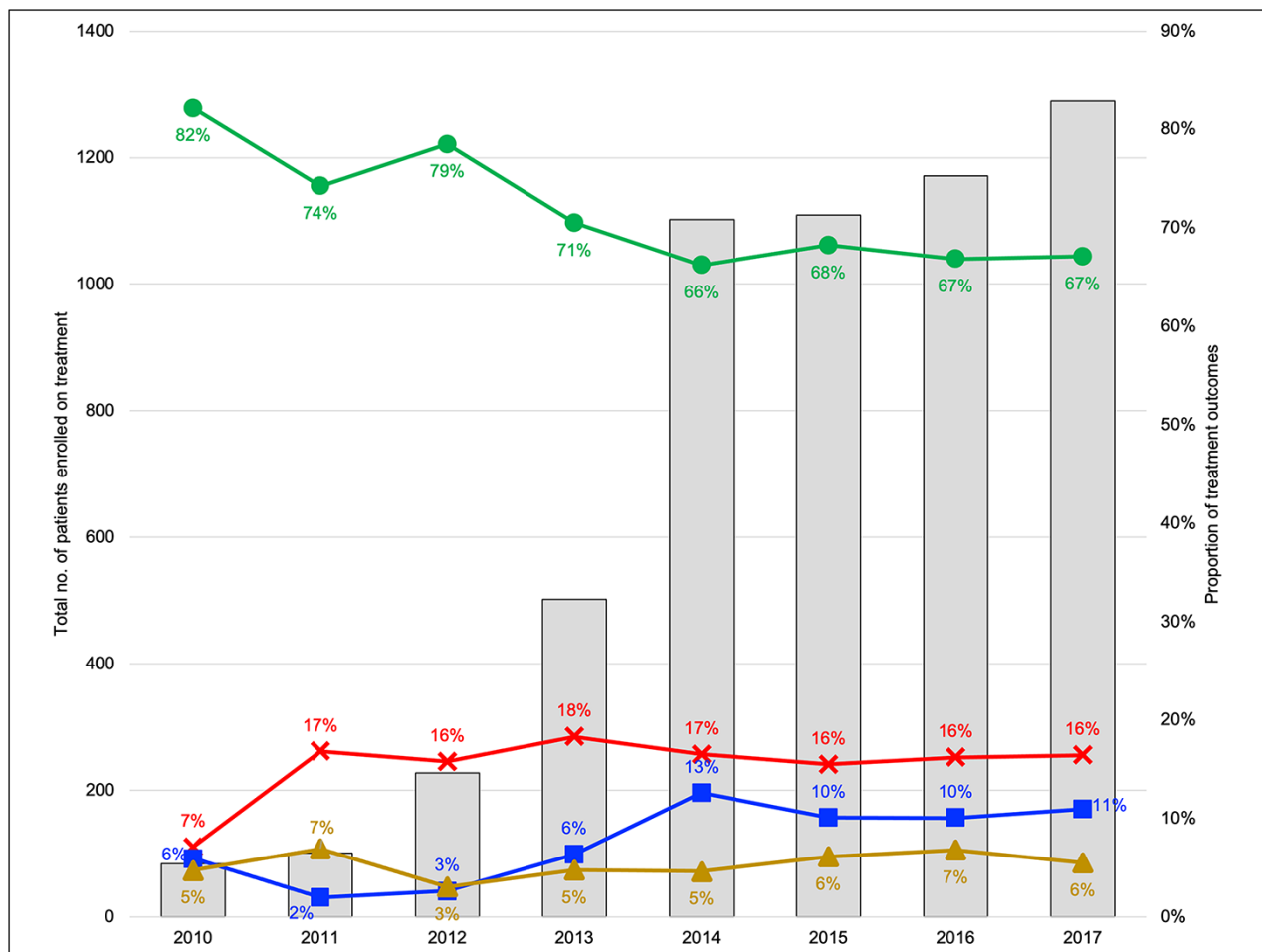


Figure 2. Annual trends in MDR-TB patient enrolments and treatment outcomes (2010–2017). Legend: Outcomes are reported for cohort enrolled in the specified year

illustrated in Figure 4. The association between distance to the treatment facility and an unfavourable treatment outcome remained after restriction to patients who lived within 250 km of treatment facilities (Model 2: adjusted relative risk 1.015; 95% CI 1.000–1.030).

Discussion

We report findings from routine programmatic data collected on RR/MDR-TB patients from 2010 to 2017 in two of the largest provinces (Sindh and Balochistan) in Pakistan. Although the number of DR-TB treatment sites increased from 1 in 2010 to 11 in 2017, resulting in shorter travel distances for patients, overall treatment success rates decreased over time and the rate of lost to follow-up increased. Therefore, while expanding DR-TB services at a rapid rate may appear desirable, if not paired with a concurrent rise in high-quality community-based care close to where patients live or work, it may not improve the quality of clinical care and treatment outcomes. For the most vulnerable, the distance to care facilities may represent an insurmountable barrier (Thomas *et al.*, 2016; Furin *et al.*, 2020). Of note, patients and their treatment supporters (usually family members) only received a fixed rate of PKR 600 (less than USD 4) in travel allowance

per follow-up visit. This is grossly insufficient, especially when larger distances are involved. Despite the perception that scaling up of services would decrease travel, patients continued to travel long distances (with a median distance of approximately 120 km for a round trip in peri-urban/rural areas) by the end of the expansion period.

Few studies have looked at the association of distance from treatment facilities on DR-TB treatment outcomes in Pakistan. Iqbal *et al.* found that distance to treatment sites was associated with unfavourable treatment outcomes, and our analysis replicates these findings (Iqbal *et al.*, 2020). However, we assessed the driving distance from patient's actual residence to the treatment facility rather than the region (areal unit), thereby minimizing the measurement error of the exposure.

With patients located so far from treatment facilities, the treatment coordinator's role assumes even greater importance in the provision of high-quality DR-TB care (Lyakurwa *et al.*, 2021). In our programme, we used trained treatment coordinators to monitor treatment supporters, perform contact tracing and track those lost to follow-up. However, as the programme expanded, the treatment coordinators were insufficient for the increasing number of patients; one coordinator often had to support several districts and as many as 250 DR-TB patients. In the absence of appropriate resources and a

Median Driving Distance from Patient Residence to DR-TB Treatment Site

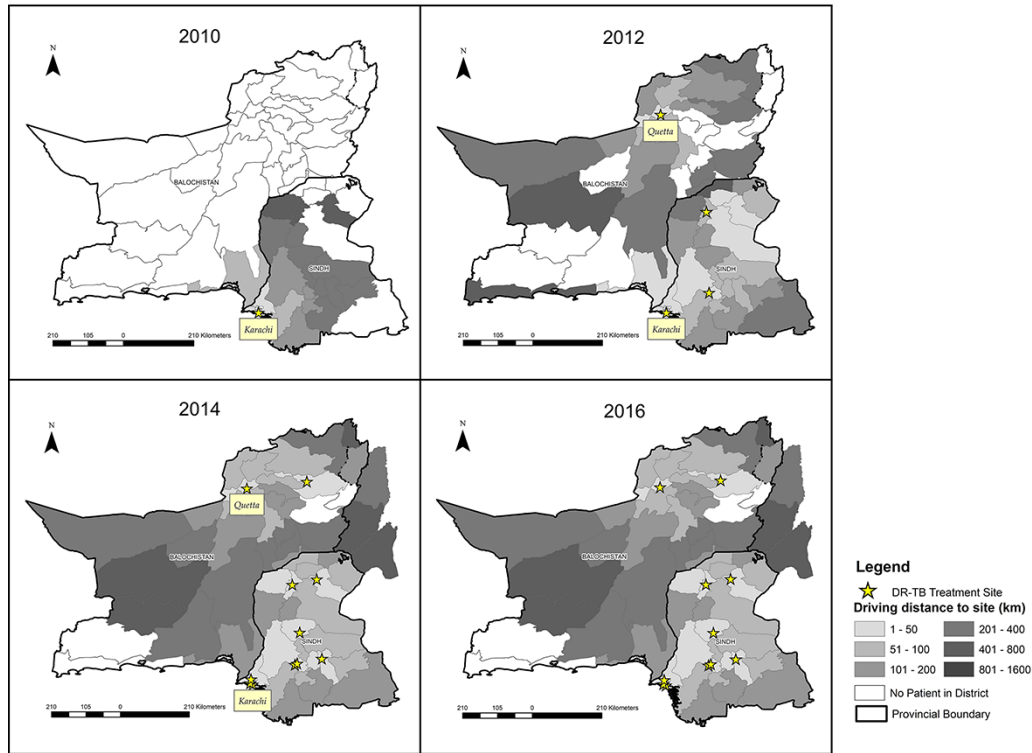


Figure 3. Median driving distance from patient residence to DR-TB treatment site

Table 2. Crude and multivariable analysis for the association of driving distance and an unfavourable RR/MDR-TB treatment outcome

Distance to treatment facility	Multivariable analysis ^a							
	Crude analysis		Model 1: All patients (n = 5582)			Model 2: Restricted to patients who are resident within 250 km of treatment facility (n = 5271)		
	Crude risk ratio	95% CI	Adjusted risk ratio	95% CI	P-value	Adjusted risk ratio	95% CI	P-value
Every 20 km	1.017	1.009–1.026	1.013	1.005–1.022	0.001	1.015	1.000–1.030	0.040

^aAdjusted for age, sex, year of registration, FQ resistance, advanced disease at diagnosis (3+ smear-positive ± cavitation on chest x-ray), extrapulmonary or pulmonary disease, prior exposure to second-line regimen and treatment site.

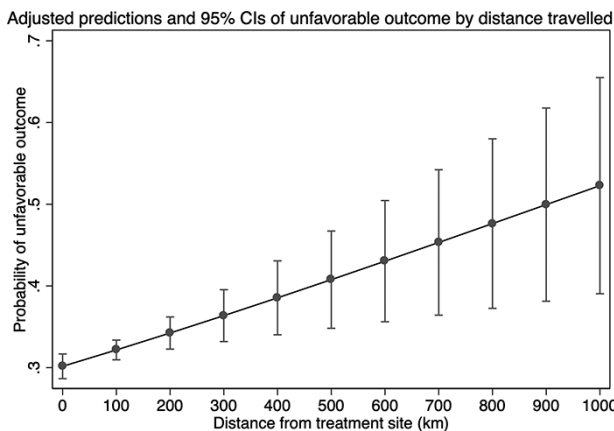


Figure 4. Adjusted predictions and 95% CIs of unfavourable outcome by distance travelled

strategy aligned to local circumstances, expansion by itself creates barriers for health workers in the implementation of community activities (Vanleeuw *et al.*, 2020).

Our study shows RR/MDR-TB patients residing in peri-urban or rural settings had a 29% higher risk of unfavourable outcomes compared with urban areas of Karachi. As the programme expanded facilities from urban areas to rural Sindh province, the distribution of patient characteristics in terms of area/type of residence, drug resistance profile and treatment history also changed. However, such changes were not accompanied by resources to address them. For example, while access to Xpert MTB/Rif testing expanded (albeit slowly), it was not adequately supported with resources for clinical monitoring (Supplementary Table S1). Several routine investigations to monitor people on second-line RR/MDR-TB drugs were often unavailable on site, leading to out-of-pocket expenses for vulnerable, poor DR-TB patients.

Moreover, once patients were identified in hard-to-reach rural areas, there were logistical challenges identified in transporting sputum specimens for culture and drug-susceptibility testing.

Appropriate investment and time are needed to carefully design and implement decentralized, locally driven solutions that are balanced with appropriate access to resources for DR-TB care at each health administrative level (Scheffer *et al.*, 2018). While the decentralization of services to all districts may appear unfeasible, it is in fact the perfect opportunity for innovation utilizing existing resources. Possible approaches may include e.g. implementing telemedicine and/or mobile vans, training and incentivizing district health staff on routine follow-up and TB-related queries, sharing care platforms with other diseases (e.g. diabetes and hepatitis C) and using couriers to deliver medications or to collect samples for testing (Gray *et al.*, 2020). Moreover, operational research opportunities can help evaluate local solutions. Such opportunities can also support the need for mentorship and help develop local ownership.

While resources are essential, these alone cannot overcome issues with the centralized models of care we highlight (Lurie *et al.*, 2021). We also need to emphasize patient-near care delivery as a core principle of disease control programmes, especially for infectious diseases such as DR-TB. This is an important opportunity to partner with civil society organizations in developing solutions and solving issues locally (De Vries *et al.*, 2017). As one such opportunity, in Balochistan province in Pakistan, there are 34 districts served by two DR-TB treatment facilities centralized in two districts. However, at any given time, there are DR-TB patients in each of the other 32 districts unable to access care close to their homes. The use of telemedicine models for care delivery in such hard-to-reach areas should be explored. This also underscores the need for lessons learnt from implementing in such diverse populations so that issues leading to delays in diagnosis and access to newer, better treatments can be addressed before services are scaled up (Furin *et al.*, 2016).

Shifting the overall programme strategy towards patient-near care delivery and community engagement is an important step towards universal health care (Alpert *et al.*, 2020; Ehrenkranz *et al.*, 2021). For example, a known barrier to identifying and treating all forms of paediatric TB (including DR-TB) is the lack of access to community-level services. Approaches such as creating a framework of trained health workers for integrated contact screening and TB preventive therapy can increase paediatric TB case detection (Zawedde-Muyanja *et al.*, 2018). Such interventions may also help reduce any stigma by increasing access to care close to their homes (Craig *et al.*, 2017). Another critical and neglected area that requires community-driven approaches and has yet to be integrated into routine DR-TB care is the need for palliative and end-of-life care support for DR-TB patients who have unfavourable treatment outcomes (Hughes and Snyman, 2018). Solutions through community engagement with representation from affected groups, health sectors and genders may also have several benefits to support end-of-life care and can ensure local, more compassionate and ethical solutions to prevent the transmission of highly resistant strains in the community.

Such approaches can benefit all health conditions and not just communicable diseases, including TB. Treatment for DR-TB requires a system capable of delivering integrated care—between medical subspecialties, laboratory and care delivery systems. Since many countries struggling with the spread of RR/MDR-TB have weak health systems, programmes have had to build platforms or pilot strategies to design a spectrum of integrated care for patients (Byrne *et al.*, 2018; Calligaro *et al.*, 2021). Such integrated practices can strengthen not only TB programmes but also the management of other infectious and chronic diseases (Geiger *et al.*, 2021). Since patients with TB often suffer from other treatable conditions such as diabetes, HIV/AIDS and viral hepatitis, it helps tie together these conditions within a common approach, avoiding the pitfalls of vertical programmes. Importantly, this re-engages patients with locally available public health programmes, e.g. primary care and mental health programs.

Our study has several limitations: most notably the use of retrospective, routine programmatic data. Other unmeasured confounders over time included the change of standard of care for DR-TB treatment, variation in clinical monitoring across sites and socio-political factors that may have impacted routine care. Other factors in peri-urban/rural areas such as reduced access to basic health services, including TB care, poor infrastructure and utilities, may also contribute to unfavourable treatment outcomes as compared to urban areas (Sudha *et al.*, 2003; Cambanis *et al.*, 2005; Mushtaq *et al.*, 2011). However, this was a large, diverse dataset, including both rural, peri-urban and urban populations. Few studies have looked at the association of distance from treatment facilities on DR-TB treatment outcomes in Pakistan.

Conclusion

Our findings suggest that extending DR-TB services through centralized hubs of care delivery likely increased unfavourable outcomes for people accessing care in peri-urban and rural districts. Unfortunately, in many low- and low-middle-income countries, national TB control programme priorities for the diagnosis and management of DR-TB are driven by centralized models that do little to push comprehensive care—the ability to diagnose and treat all forms of TB—out to the communities where people with TB disease and infection live and work. The provision of DR-TB care requires rethinking of the current model, which is heavily dependent on global financing led by the Global North, thus limiting local voices and solutions. Moreover, donor financing mechanisms perpetuate this situation and impede the inclusion of communities in decision-making (Khan *et al.*, 2018). It has taken the COVID-19 pandemic, also caused by a respiratory pathogen, to reassert the critical importance of flexible, timely, context-specific solutions and the value of expanding diagnostic and treatment capabilities in the communities where people live and work (Sigfrid *et al.*, 2020). Locating services closer to the community can increase case detection, prevent DR-TB transmission and enhance community engagement (Ardizzoni *et al.*, 2015; Mbuthia *et al.*, 2018). Thus, we advocate for decentralized services for DR-TB that are locally accessible and integrated with local processes, reducing overall costs to

both health providers and patients to improve treatment outcomes (Ho *et al.*, 2017). Thus, the local ecology of healthcare will be strongly supported and sustained to the benefit of all health conditions.

Supplementary data

Supplementary data are available at *Health Policy and Planning* online.

Data availability

The data underlying this article are available in the article and in its online supplementary material.

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Reflexivity statement

As a low- and middle-income country, with the fourth highest MDR/RR-TB incidence worldwide, the Pakistan Ministry of Health declared TB as a national emergency in 2001, with case notification of MDR/RR-TB cases a key performance indicator. Our manuscript thus addresses research and policy priorities in Pakistan. This study has been conceptualized, designed and implemented entirely by a fully local team of TB-infectious disease clinicians, epidemiologists, laboratory scientists and public sector experts living or working in Pakistan. Thirteen out of the 21 (62%) authors on this paper are Pakistani female researchers and clinicians. Most of the authors (70%) are early career researchers who have benefited through mentorship by senior colleagues in this study.

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