



# Treatment outcomes of pregnant women with drug-resistant tuberculosis in Uganda: A retrospective review of 18 cases



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## ABSTRACT

**Background:** There is a dearth of reports on drug-resistant tuberculosis (DRTB) treatment outcomes among pregnant women in tuberculosis (TB)/HIV high-burdened countries. We report treatment outcomes of 18 pregnant women with DRTB in Uganda.

**Methods:** We reviewed charts of individuals who received DRTB treatment in Uganda across 16 DRTB treatment sites. We included all women who were pregnant during DRTB treatment and had a treatment outcome documented between 2013 and 2019.

**Results:** There were 18 pregnant women with a mean age (standard deviation (SD)) of 27.5 (5.2) years, of whom 8 (44.4%) were HIV co-infected. Among these women, 12 (66.7%) had primary DRTB and 8 (44.4%) had multidrug-resistant TB. Levofloxacin (Lfx), Pyrazinamide, Cycloserine and Kanamycin (Kn) were the most (>78%) used drugs in the treatment regimen and the mean (SD) treatment duration was 17.6 (7.5) months. Elevated liver enzymes (81.8%, n = 11) and hearing loss (33.3%, n = 15) were the most frequently encountered drug adverse events. Treatment success was observed among 15 (83.3%) patients, 2 (11.1%) patients were lost to follow up and 1 (5.6%) patient died.

**Conclusion:** The treatment success among pregnant women with DRTB in Uganda was high despite a high prevalence of HIV co-infection.

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## Background

Drug-resistant tuberculosis (DRTB) is an emerging threat to tuberculosis (TB) control and an estimated half a million incident cases occurred in 2019 globally (World Health Organization, 2020). In sub-Saharan Africa, the pooled prevalence of DRTB is 12.6% among new TB cases (Lukoye et al., 2015). The programmatic management of DRTB is plagued by low rates of drug susceptibility testing (DST), low notification of cases and the global treatment success rate is consistently lower than 60% (World Health Organization, 2019a, 2020). Additionally, DRTB treatment is complex, expensive, lengthy and associated with several toxicities particularly among patients with comorbid conditions (Esmail et al., 2018). For that reason, individualised regimens that take into account the disease severity, concurrent medications and risk of

adverse events are recommended for sub-group populations such as children, HIV co-infected and pregnant women (World Health Organization, 2019b).

Among pregnant women, Amikacin, Streptomycin and Ethionamide (Eto)/Proethionamide are contraindicated while there is still little knowledge on the safety of newer agents (Bedaquiline (BDQ) and Delamanid) (World Health Organization, 2019b). There is no consensus on the optimal DRTB treatment regimen among pregnant women and data on efficacy, safety, tolerability and maternal and foetal outcomes are needed (Nahid et al., 2019). Currently, there are few reports on the treatment outcomes of pregnant DRTB patients. A systematic review that included 65 pregnant women with DRTB reported a treatment success rate of 69% and live births were observed among 79% of the patients (Nahid et al., 2019). However, a more recent systematic review of 174 women reported the prevalence of maternal deaths, pregnancy loss, preterm death and low birth weight to be 7.5%, 10.6%, 12.9% and 23.7%, respectively (Alene et al., 2020). Unfortunately, there are few reports from TB/HIV high-burdened settings, all of which are from South Africa (Khan et al., 2007; Loveday et al., 2020; van

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der Walt et al., 2020). The DRTB treatment success rates from these reports was 65%–67% and 88%–91% of pregnancies that resulted in live births (Loveday et al., 2020; van der Walt et al., 2020). More reports on treatment and pregnancy outcomes among pregnant women with DRTB from TB/HIV high-burdened countries are needed. Uganda is a TB/HIV high-burdened country where 52%–62% patients with DRTB are co-infected with HIV (Baluku et al., 2020; Kasozi et al., 2020; Okethwangu et al., 2019). The cumulative number of patients with DRTB enrolled in care was 1352 by 2017, which averaged 225 patients annually, and the treatment success rate has been consistently >70% (Kasozi et al., 2020). In this study, we report characteristics and treatment outcomes of 18 pregnant women who were managed for DRTB in Uganda between 2013 and 2019.

## Methods

### Study setting and population

This was part of a larger countrywide retrospective review of patients' charts from 16 of 17 DRTB treatment sites in Uganda (Baluku et al., 2021). In this study, eligible patients were all pregnant women with laboratory-confirmed DRTB who had a documented treatment outcome between 2013 and 2019. Pregnancy was confirmed by commercially available urine human chorionic gonadotropin tests. DRTB was diagnosed using Xpert MTB/RIF assay and conventional *Mycobacterium* culture on sputum samples. There were no exclusion criteria. The programmatic management of DRTB in Uganda began in 2013 and DRTB treatment is offered at 16 public hospitals and 1 private not-for-profit hospital. Facility-based directly observed therapy is the main model of treatment adherence and adverse effect monitoring and local DRTB treatment guidelines (Ministry of Health, 2011, 2016, 2017) have been in tandem with the World Health Organisation (WHO) guidelines.

### Diagnosis and management of DRTB among pregnant women

After an initial molecular drug susceptibility test (Xpert MTB/RIF or line probe assays) that showed resistance to the first-line agents, a second sample was transported to the National Tuberculosis Reference Laboratory for phenotypic culture-based DST. All women of childbearing age were required to have a pregnancy test done before the initiation of DRTB treatment. All were empirically initiated on a standardised DRTB treatment regimen as per national guidelines after the molecular DST. Upon receipt of the phenotypic DST, the regimen was individualised (if need be) according to the drug susceptibility pattern. Among pregnant women, earlier Uganda DRTB treatment guidelines (Ministry of Health, 2011, 2016) recommended initiating the DRTB therapy in the second trimester or sooner if the patient was deemed to be severely sick. However, we were unable to establish the gestation age at which therapy was initiated for women who were pregnant at the time of treatment initiation. Injectable agents and Eto were not recommended due to ototoxicity (to the mother and foetus) and worsening of pregnancy-related gastrointestinal symptoms, respectively. If there was no alternative to the injectable agent, Capreomycin was the preferred drug of choice. By 2019, there were 4 standardised regimens: (1) a standardised shorter treatment regimen, introduced in 2016 (Ministry of Health, 2017), of 9–11 months with 4–6 months of Kn, Moxifloxacin (Mfx), Eto, High-dose Isoniazid (HHD), Clofazimine, Pyrazinamide (Z) and Ethambutol (E) followed by 5 months of Mfx/Cfz /E/Z; (2) a conventional treatment regimen of 20–24 months with 6–8 months of Kn/Lfx/Eto/Cs/Z followed by 14–16 months of Lfx/Cs/Eto/Z and (3) an oral BDQ-based regimen of 9 months with BDQ/

Linezolid/Lfx/Cfz/Cs (Ministry of Health, 2019) for which no constituent drug was contraindicated in pregnancy.

Therapy was initiated at a DRTB treatment initiation site. Patients were briefly admitted at these sites (typically for less than a month), to perform preliminary work up and identify a peripheral follow-up facility (FUF) near the patient's homestead for the continuation of care. Directly observed therapy was administered by health workers at the peripheral FUF. Women were monitored monthly for clinical improvement (signs and symptoms), sputum conversion (sputum cultures) and side effects (serum creatinine, liver transaminases, full haemogram and audiometry). Further details of DRTB management in Uganda are described elsewhere (Baluku et al., 2021; Kasozi et al., 2020).

### Study measurements

By using a data abstraction form, sociodemographic and clinical data were extracted from the patient charts. Data on age, sex, year of treatment initiation, employment and marital status were obtained. Additionally, data on previous TB episode, HIV status and treatment, other comorbid conditions, baseline TB resistance profile, drugs used in the treatment regimen, drug adverse events, treatment duration, time to culture conversion and treatment outcomes were extracted. Women were routinely monitored for hearing loss, hepatic injury, renal dysfunction and anaemia.

In this analysis, hepatic injury was defined as elevation in any of total bilirubin, aspartate aminotransferase, gamma-glutamyl transferase, alanine aminotransferase and alkaline phosphatase at the respective cut offs of: >2.5 mg/dL, >34.8 U/L, >68.5 U/L, >42.8 U/L and >151 U/L (Eller et al., 2008). Renal dysfunction was defined as any creatinine level >106.1 µm/L (Eller et al., 2008). A haemoglobin level of ≤8.0 g/dL was considered to be severe anaemia (World Health Organization, 2011). Hearing loss was monitored using pure tone audiometry. Treatment outcomes were cure, treatment completion, death, loss to follow up and treatment failure as defined by World Health Organization (2013). Treatment success was defined as a sum of cure and treatment completion.

### Statistical analysis

Data were analysed using Stata 15.0 (STATA, College Station, Texas, USA). A descriptive approach was undertaken, and data were summarised as proportions and means with corresponding SDs for categorical and continuous variables, respectively.

### Consent and ethical approval

The primary study was proved by the Mulago Hospital Research and Ethics Committee (#MHREC 1679), which provided waiver of consent for the use of secondary data.

## Results

### Sociodemographic characteristics of pregnant women with DRTB in Uganda

Eighteen pregnant women with DRTB were enrolled, of whom 6 (33.3%) were pregnant at treatment initiation. The mean age (SD) was 27.5 (5.2) years and 12 (66.7%) patients had no history of previous TB treatment. All 6 patients with previous TB treatment had been treated with first-line agents (combination of rifampicin, isoniazid, ethambutol and pyrazinamide). Other sociodemographic characteristics are shown in Table 1.

**Table 1**  
Sociodemographic characteristics of pregnant women with DRTB in Uganda.

| Characteristic (N = 18)      | n (%)     |
|------------------------------|-----------|
| DR–TB treatment site         |           |
| National referral hospital   | 5 (27.8)  |
| Regional referral hospital   | 10 (55.6) |
| District hospital            | 3 (16.7)  |
| Age (years), n = 17          |           |
| 15–34                        | 15 (88.2) |
| 35–60                        | 2 (11.8)  |
| Residence                    |           |
| Rural                        | 13 (72.2) |
| Urban                        | 5 (27.8)  |
| Employment status, n = 17    |           |
| Unemployed                   | 12 (70.6) |
| Self employed                | 3 (17.6)  |
| Formal employment            | 2 (11.8)  |
| Marital status               |           |
| Married                      | 13 (72.2) |
| Not Married                  | 5 (27.8)  |
| History of TB treatment      |           |
| Yes                          | 12 (66.7) |
| No                           | 6 (33.3)  |
| Year of treatment initiation |           |
| ≤2013                        | 1 (5.6)   |
| 2014                         | 2 (11.1)  |
| 2015                         | 2 (11.1)  |
| 2016                         | 3 (16.7)  |
| 2017                         | 3 (16.7)  |
| 2018                         | 5 (27.8)  |
| 2019                         | 2 (11.1)  |

### Clinical characteristics of pregnant women with DRTB in Uganda

Among the women, 8 (44.4%) were HIV co-infected and were all on antiretroviral therapy (7 were on tenofovir disoproxil/lamivudine/efavirenz and 1 was on Zidovudine, Emtricitabine and Nevirapine) and cotrimoxazole prophylaxis before DRTB treatment initiation. The mean (SD) baseline body mass index (BMI) was 19.0 (3.6) kg/m<sup>2</sup> (n = 10) and 5 (50%) patients had BMI < 18.5 kg/m<sup>2</sup>. The mean (SD) duration from DRTB diagnosis to treatment initiation was 13.0 (10.3) days (n = 15), while the mean (SD) treatment duration and time to sputum conversion was 17.6 (7.5) and 2.1 (2.4) months, respectively. The commonest side effect was hepatic injury that occurred in 9 (81.8%) women, 6 (33.3%) women experienced no side effects, and among those women with side effects, 6 (50.0%) had ≥2 side effects. Other clinical characteristics are shown in [Table 2](#).

### Treatment outcomes of pregnant women with DRTB in Uganda

Of all the pregnant women, 14 (77.8) were cured, 2 (11.1) were lost to follow up, 1 (5.5%) completed treatment and 1 (5.5%) died. Therefore, the treatment success rate was 83.3%. There was no case of treatment failure.

## Discussion

The objective of this study was to describe the characteristics and treatment outcomes of pregnant women with DRTB in Uganda, a TB/HIV high-burdened country. We report a treatment success rate of 83% even though 44% of the cohort were co-infected with HIV. In 2014, it was estimated that there were 1400–4400 pregnant women with TB in Uganda ([Sugarman et al., 2014](#)). However, the incidence of DRTB and treatment outcomes among pregnant women in Uganda are not well established. This study is therefore the first to report on DRTB among pregnant women in Uganda. Our treatment success was higher than that observed among 38 pregnant women in Peru (74%) ([Palacios et al., 2009](#)). In South

**Table 2**  
Clinical characteristics of pregnant women with DRTB in Uganda.

| Clinical characteristic (N = 18)                         | n (%)      |
|----------------------------------------------------------|------------|
| Body mass index, mean (SD), kg/m <sup>2</sup> and n = 10 | 19.0 (3.6) |
| Type of DRTB at baseline                                 |            |
| Rifampicin resistance                                    | 9 (50.0)   |
| MDRTB                                                    | 8 (44.4)   |
| Poly-resistant tuberculosis                              | 1 (5.6)    |
| Resistance at baseline                                   |            |
| Rifampicin                                               | 18 (100)   |
| Isoniazid                                                | 8 (44.4)   |
| Streptomycin                                             | 1 (5.6)    |
| Ethambutol                                               | 3 (16.7)   |
| Pyrazinamide                                             | 1 (5.6)    |
| Second-line aminoglycoside                               | 1 (5.6)    |
| Drugs in treatment regimen                               |            |
| Kanamycin                                                | 13 (72.2)  |
| Levofloxacin                                             | 16 (88.9)  |
| Ethambutol                                               | 3 (16.7)   |
| Clofazimine                                              | 4 (22.2)   |
| High-dose isoniazid                                      | 2 (11.1)   |
| Capreomycin                                              | 5 (27.8)   |
| Cycloserine                                              | 16 (88.9)  |
| Linezolid                                                | 1 (5.6)    |
| Pyrazinamide                                             | 17 (94.4)  |
| High-dose isoniazid                                      | 2 (11.1)   |
| Moxifloxacin                                             | 2 (11.1)   |
| Drug adverse effects                                     |            |
| Hepatic injury, n = 11                                   | 9 (81.8)   |
| Hearing loss, n = 15                                     | 5 (33.3)   |
| Psychiatric symptoms                                     | 3 (16.7)   |
| Renal dysfunction, n = 12                                | 1 (8.3)    |
| Severe anaemia, n = 11                                   | 1 (9.1)    |

Africa, a TB high-burdened country, treatment success was 65%–67%, far below our reported proportion ([Loveday et al., 2020](#); [van der Walt et al., 2020](#)). This could be because we had a lower proportion of women with HIV co-infection (44% vs. 76.9% ([van der Walt et al., 2020](#)) and 81% ([Loveday et al., 2020](#))), all of whom were started on ART and cotrimoxazole prophylaxis before DRTB treatment initiation. In addition, these studies included patients with extensively drug-resistant TB. It is worth noting that DRTB treatment success in Uganda was 74% in the 2017 cohort, which was way above the global estimate of 57% ([World Health Organization, 2020](#)) and therefore, it is not surprising that pregnant women with DRTB in Uganda also had a higher rate of treatment success. Additionally, while there was a high prevalence of HIV among pregnant women in our study, the proportion is lower than the 53%–59% reported among nationwide DRTB cohorts whose treatment success rate was >70% ([Baluku et al., 2021](#); [Kasozi et al., 2020](#)). Even among people with TB/HIV co-infection in Uganda, regardless of pregnancy status, the treatment success rate is 74% ([Musaazi et al., 2017](#)). Moreover, Uganda has implemented an enablers program for DRTB patients since 2015 to foster treatment adherence. Further, pregnant women are closely monitored by clinicians and the local national DRTB consilium (a multidisciplinary panel of experts who provide expert opinion and consensus on the best treatment options).

From the patients' charts, we could not determine the pregnancy outcomes of the women in our cohort because this was not documented. Notwithstanding, febrile illnesses during pregnancy are associated with a higher risk of poor pregnancy outcomes among people with HIV in Uganda ([Lancaster et al., 2015](#)). It is, therefore, important that programs proactively monitor and document pregnancy outcomes as DRTB and its treatment can result in foetal demise and low birth weight ([Alene et al., 2020](#)). While 84% of babies born to pregnant women with DRTB were reported to be thriving at 1 year ([Loveday et al., 2020](#)), it may be necessary to evaluate long-term neurocognitive development of children exposed to second-line agents in utero or during lactation.

Although our cohort was small, hearing loss and psychiatric symptoms were observed among the women, yet the culprit agents (aminoglycosides and cycloserine (Cs), respectively) cross the placenta. Future studies could further document pregnancy outcomes among pregnant women with DRTB/HIV co-infection.

This study has limitations. Clearly, our cohort is small, and no inferences can be made with regard to optimal treatment regimens or anticipated adverse events. Nevertheless, it contributes to the few available studies among pregnant DRTB women from TB/HIV high-burdened countries. We were unable to evaluate pregnancy outcomes, and therefore, a high TB treatment success among the women does not reflect optimal DRTB treatment outcomes for the foetus. Pregnancy outcomes were not available to enable us to perform an analysis for pregnancy outcomes.

## Conclusion

The treatment success among pregnant women with DRTB in Uganda was high despite a high prevalence of HIV co-infection. Large studies are needed to determine predictors of treatment success among pregnant women with DRTB.

## Availability of data

Datasets used in this analysis are available from the corresponding author upon reasonable request.

## Authors' contribution

JBB – Conceptualisation, methodology, data accrual, formal analysis, interpretation of results and drafting the manuscript. FB – Methodology, formal analysis, interpretation of results and manuscript review.

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## Conflict of interests

The authors declare no conflict of interests.

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## References

- Alene KA, Jegnie A, Adane AA. Multidrug-resistant tuberculosis during pregnancy and adverse birth outcomes: a systematic review and meta-analysis. *BJOG* 2020;., doi:<http://dx.doi.org/10.1111/1471-0528.16573>.
- Baluku JB, Mugabe P, Mulwana R, Nassozi S, Katuramu R, Worodria W. High prevalence of rifampicin resistance associated with rural residence and very low bacillary load among TB/HIV-coinfected patients at the National Tuberculosis Treatment Center in Uganda. *BioMed Res Int* 2020;2508283, doi:<http://dx.doi.org/10.1155/2020/2508283>.
- Baluku JB, Nakazibwe B, Naloka J, Nabwana M, Mwanja S, Mulwana R, et al. Treatment outcomes of drug resistant tuberculosis patients with multiple poor prognostic indicators in Uganda: a countrywide 5-year retrospective study. *J Clin Tuberc Other Mycobact Dis* 2021;100221, doi:<http://dx.doi.org/10.1016/j.jctube.2021.100221>.
- Eller LA, Eller MA, Ouma B, Kataaha P, Kyabaggu D, Tumusiime R, et al. Reference intervals in healthy adult Ugandan blood donors and their impact on conducting international vaccine trials. *PLoS One* 2008;3:e3919, doi:<http://dx.doi.org/10.1371/journal.pone.0003919>.
- Esmail A, Sabur NF, Okpechi I, Dheda K. Management of drug-resistant tuberculosis in special sub-populations including those with HIV co-infection, pregnancy, diabetes, organ-specific dysfunction, and in the critically ill. *J Thorac Dis* 2018;10:3102–18, doi:<http://dx.doi.org/10.21037/jtd.2018.05.11>.
- Kasozi S, Kirirabwa NS, Kimuli D, Luwaga H, Kizito E, Turyahabwe S, et al. Addressing the drug-resistant tuberculosis challenge through implementing a mixed model of care in Uganda. *PLoS One* 2020;15:e0244451, doi:<http://dx.doi.org/10.1371/journal.pone.0244451>.
- Khan M, Pillay T, Moodley J, Ramjee A, Padayatchi N. Pregnancies complicated by multidrug-resistant tuberculosis and HIV co-infection in Durban, South Africa. *Int J Tuberc Lung Dis* 2007;11:706–8.
- Lancaster KE, Kwok C, Rinaldi A, Byamugisha J, Magwali T, Nyamapfeni P, et al. Incident pregnancy and pregnancy outcomes among HIV-infected women in Uganda and Zimbabwe. *Int J Gynaecol Obstet* 2015;131:255–9, doi:<http://dx.doi.org/10.1016/j.ijgo.2015.06.035>.
- Loveday M, Hughes J, Sunkari B, Master I, Hlangi S, Reddy T, et al. Maternal and infant outcomes among pregnant women treated for multidrug/rifampicin-resistant tuberculosis in South Africa. *Clin Infect Dis* 2020;ciaa189, doi:<http://dx.doi.org/10.1093/cid/ciaa189>.
- Lukoye D, Ssengooba W, Musisi K, Kasule GW, Cobelens FGJ, et al. Variation and risk factors of drug resistant tuberculosis in sub-Saharan Africa: a systematic review and meta-analysis. *BMC Public Health* 2015;15:291, doi:<http://dx.doi.org/10.1186/s12889-015-1614-8>.
- Ministry of Health. Uganda national guidelines for the programmatic management of drug resistant tuberculosis. 2011.
- Ministry of Health. Uganda national guidelines for the programmatic management of drug resistant tuberculosis. 2nd ed. 2016.
- Ministry of Health. Short treatment regimen (STR) for MDR-TB: annex 9. Uganda national guidelines for the programmatic management of drug resistant tuberculosis. .
- Ministry of Health. Addendum to the national guidelines for the programmatic management of drug-resistant tuberculosis. Kampala, Uganda: Ministry of Health of Uganda; 2019.
- Musaazi J, Kiragga AN, Castelnuovo B, Kambugu A, Bradley J, Rehman AM. Tuberculosis treatment success among rural and urban Ugandans living with HIV: a retrospective study. *Public Health Action* 2017;7:100–9, doi:<http://dx.doi.org/10.5588/pha.16.0115>.
- Nahid P, Mase SR, Migliori GB, Sotgiu G, Bothamley GH, Brozek JL, et al. Treatment of drug-resistant tuberculosis. An official ATS/CDC/ERS/IDSA clinical practice guideline. *Am J Respir Crit Care Med* 2019;200:e93–e142, doi:<http://dx.doi.org/10.1164/rccm.201909-1874ST>.
- Okethwangu D, Birungi D, Biribawa C, Kwesiga B, Turyahabwe S, Ario AR, et al. Multidrug-resistant tuberculosis outbreak associated with poor treatment adherence and delayed treatment: Arua District, Uganda, 2013–2017. *BMC Infect Dis* 2019;19:387, doi:<http://dx.doi.org/10.1186/s12879-019-4014-3>.
- Palacios E, Dallman R, Munoz M, Hurtado R, Chalco K, Guerra D, et al. Drug-resistant tuberculosis and pregnancy: management and treatment outcomes of 38 cases in Lima, Peru. *Clin Infect Dis* 2009;48:1413–9, doi:<http://dx.doi.org/10.1086/598191>.
- Sugarman J, Colvin C, Moran AC, Oxlade O. Tuberculosis in pregnancy: an estimate of the global burden of disease. *Lancet Glob Health* 2014;2:e710–6, doi:[http://dx.doi.org/10.1016/S2214-109X\(14\)70330-4](http://dx.doi.org/10.1016/S2214-109X(14)70330-4).
- van der Walt M, Masuku S, Botha S, Nkwenika T, Keddy KH. Retrospective record review of pregnant women treated for rifampicin-resistant tuberculosis in South Africa. *PLoS One* 2020;15:e0239018, doi:<http://dx.doi.org/10.1371/journal.pone.0239018>.
- World Health Organization. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. World Health Organization; 2011.
- World Health Organization. Definitions and reporting framework for tuberculosis–2013 revision (No. 9241505346). World Health Organization; 2013.
- World Health Organization. Global tuberculosis report 2019. Global tuberculosis report 2019. .
- World Health Organization. WHO consolidated guidelines on drug-resistant tuberculosis treatment. World Health Organization; 2019.
- World Health Organization. Global tuberculosis report 2020. Global tuberculosis report 2020. .