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RESEARCH ARTICLE

TUBERCULOSIS CASE FINDING AND MANAGEMENT IN PUBLIC HEALTH CARE FACILITIES IN GHANZI SUB-DISTRICT OF BOTSWANA

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ABSTRACT

Ghanzi Sub-district was reported to have twice the average national annual tuberculosis (TB) notification rate. Our study assesses the efficiency of passive case finding, ethnic and spatial variation in TB rates, documentation, and management of TB cases in the sub-district using historical data from health care facilities between 2006 and 2010. Descriptive statistics were performed to discern time trends, geographic variation, and variation by individual characteristics. We identified incomplete patients record keeping, heightened patients' movement between health care facilities, variation in TB incidence by sex and dominant tribe, as well as high treatment failure with corresponding rise in multidrug resistance.

KEYWORDS

tuberculosis; integrated therapy; ethnic.

1. INTRODUCTION

Tuberculosis (TB) has become an intractable public health challenge as it remained the leading cause of death from a single infectious agent globally before the advent of coronavirus (COVID-19) pandemic (WHO, 2022a). In Botswana, TB is highly endemic and although notification rates have declined from 914 per 100 000 people in 2020 to 235 per 100 000 people in 2021, it still remains amongst the highest in the world (WHO, 2023). Typically, in 2010 the national average TB notification rate was 506 cases per 100 000 population while for Ghanzi Sub-district it was estimated at 1 100 cases per 100 000 population as the highest in the country (BOPA, 2010). Risk factors of progression from exposure to infection with *Mycobacterium tuberculosis*, the causative agent of TB, are mainly of external origin to the host and determined by infectiousness of the source case, proximity to infectious case, social and behavioral risk factors that includes overcrowding, smoking, alcohol consumption and indoor air pollution.

Also, delay in diagnosis and inadequate care of TB patients by health facilities prolongs exposure to an infectious case (Narasimhan et al., 2013). Interaction between human immunodeficiency virus (HIV) and TB, where in Botswana approximately 1 in 5 adults aged between 15–49 years is living with HIV and approximately 80% of TB patients are coinfected with HIV, has increased the risk of TB infection evolving into TB disease (BNTP, 2007; Gona et al., 2020; Narasimhan et al., 2013). Upwards of 13% mortality rates of all adult TB cases and 40% amongst people living with HIV have been reported in the country (Tembo and Malangu, 2019). Compounding this, is the rising problem of multidrug resistant TB (MDR-TB) which was estimated at 0.2% amongst new TB cases and 6.1% in retreatment cases during the 1994-1997 drug resistant survey (DRS), rising to 0.8% and 10.4% in 2002, while in 2008 it was estimated at 2.5% and 6.6%, respectively (BNTP, 2007; Menzies et al., 2014). This showed a 12-fold increase in primary resistance acquisition between 1994 and 2008. Timely case detection, isolation and effective treatment of TB disease are the main means of controlling transmission, reducing incidence and limiting development of anti-TB drug resistance (Golub et al., 2005).

Passive case finding (PCF) as part of the World Health Organization (WHO)'s directly observed therapy (DOT) strategy (Volmink and Garner, 2015) is the predominant approach to TB case finding in Botswana, while the principal mode of diagnosis for TB in the country is sputum smear microscopy with grading (Ho et al., 2016; Kassa et al., 2021; WHO, 2021). This retrospective descriptive study aims to investigate the efficiency of passive case finding, documentation of TB cases, ethnic and spatial variation in TB rates, and TB management in the Ghanzi Sub-district as a means toward generating contemporary relevant aetiological hypotheses.

2. MATERIAL AND METHODS

2.1 Study Site

Ghanzi Sub-district forms part of Ghanzi District to the northwestern edge, together with Charleshill Sub-district to the southwestern edge and Central Kgalagadi Game Reserve (CKGR) to the east, and Ghanzi Township as the administrative center (Figure 1). It has an estimated total population of 29 337 and it was chosen for this study because of its more discernible tribal heterogeneity when compared to Charleshill Sub-district which is more homogenous and CKGR which is almost unpeopled (SB, 2011).

2.2 Study Population

Two main ethnic tribes are found in the Ghanzi district, the BaKgalagadi and Basarwa. BaKgalagadi tribe is largely sedentary and domicile in Ghanzi township while Basarwa dominates far-flung settlements. Basarwa are southern Africa's indigenous people and the last semi-nomadic hunter-gatherer tribe in Botswana (Crowel and Hitchcock, 1978; Knoetze and Hambira, 2018). Population of Basarwa in the Ghanzi District is estimated at 17 500 and consisting of four major clans (Lewis, 2009). Basarwa are some of the poorest and marginalized communities in Botswana with a high percentage of them living below the country's breadline of US$6.85 per person per day, experiencing low levels of literacy, and high levels of alcohol abuse (Diaz-Bonilla, 2023; Molamu and Macdonald, 1996; Hitchcock et al., 2011; Ketsitlile, 2011). Mixed tribe in this study refers to coexistent of Basarwa, BaKagalagadi and any other minority tribes in the same place (Figure 1).

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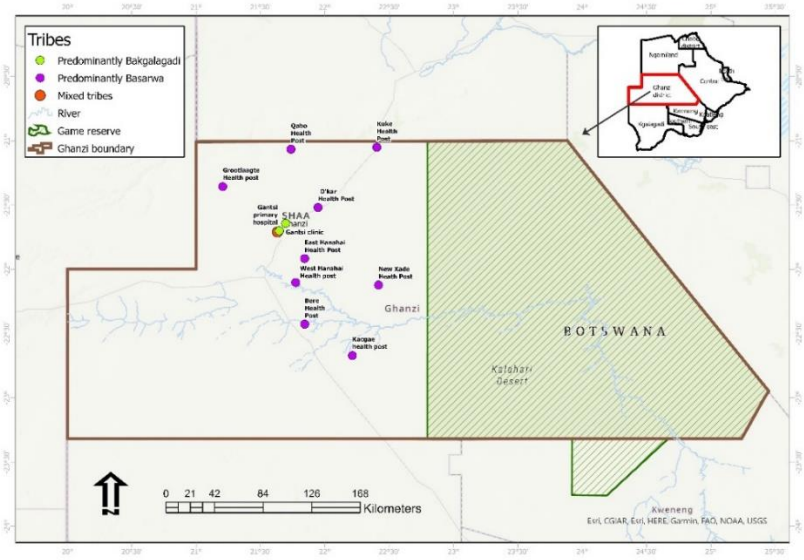

Figure 1: Map of Ghanzi District showing location of public health facilities and dominant catchment tribes (Source: Adapted from Okavango Research Institute, GIS Lab, ODIS: https://www.odis.ub.bw/portal/home).

2.3 Data Collection

Tuberculosis case data was obtained, de-identified, from unlinked electronic registers of all individuals who are contacted or were diagnosed with TB and enrolled on TB treatment at each of the 13 health care facilities located in the Ghanzi Sub-district between January 2006 and December 2010. Of the 13 health care facilities, 12 are clinics servicing local communities and one is a primary hospital that in addition to accepting walk-in patients also cares for critical cases referred from all over Ghanzi District. The registers are maintained by the Botswana National Tuberculosis Programme (BNTP) and contained case details amongst them, gender, date of registration and specimen collection, admitting facility name, HIV status, movement between facilities, smear test results and grading, and treatment outcome. Overall, the data was strong on individual identification but weak on documentation of likely confounders as there were no socio-economic parameters captured. Information on ethnicity was decided upon based on common knowledge of which ethnic tribe dominates in which locality. The population at risk for each health care facility was estimated from SB for each health care facility catchment area (SB, 2011). However, for the four health facilities located in Ghanzi Township, being Gantsi Primary Hospital, Gantsi Clinic, Prisons Clinic and SHAA Clinic, the population at risk for each of them was assumed to be that of the whole of Ghanzi Township as it was not possible to partition the base population according to the four health care facilities.

2.4 Data Analysis

Data was first cleaned to discern missing values, outliers, and incorrect entries, then analyzed descriptively to document time trends, geographical variation, and variation by individual characteristics like age, sex, and ethnicity.

3. Results

A total of 2, 632 TB patients were included in the study. In all, 347 (14.7%) patients were diagnosed with extrapulmonary TB while the rest had pulmonary TB with 286 (12.1%), 1103 (46.7%) and 973 (41.2%) testing negative, positive, and missing smear results, respectively. Missing parameter values were also noted for the following records in the TB registers; treatment regimen 2 (0.1%), treatment end date 43 (1.8%), treatment outcome 690 (29.2%), human immunodeficiency virus (HIV) status 1353 (57.3%) and sputum smear grade 979 (41.4%). Of all the sputum smear positive cases, 679 (61.6%) had 3^{+} grading. Average sensitivity for sputum test, that is proportion of true TB cases that tested positive on sputum smear test, was 79.4% (Table 1).

Table 1: Comparative analysis of sputum test performance efficiency across health care facilities in Ghanzi Sub-district showing sputum test result against associated sputum grading, with summary statistics row percentage in brackets. Not applicable grading refers to TB cases that were negative on sputum culture.

Sputum test outcome	Positive sputum TB test grade						
	Not Applicable	P+	P++	P+++	Scanty	Missing	Total
Negative	286 (100)						286 (100)
Positive		167 (15.1)	215 (19.5)	679 (61.6)	36 (3.3)	6 (0.5)	1,103 (100)
Missing						973 (100)	973 (100)
Total	286 (12.1)	167 (7.1)	215 (9.1)	679 (28.7)	36 (1.5)	979 (41.4)	2,362 (100)

At the time of patient admission for treatment in all health care facilities; 485 (20.5%), 1826 (77.3%) and 51 (2.2%) patients were moved-in to the admitting healthcare facility from another healthcare facility within Ghanzi Sub-district, newly registered at the admitting healthcare facility, and transferred-in from a healthcare facility outside Ghanzi Sub-district to the admitting healthcare facility within Ghanzi Sub-district, respectively. Reciprocally, Ghanzi Sub-district transferred out 56 (0.02%) TB patients to other districts across the country. Frequency distribution of registered tuberculosis cases in each dominant tribe catchment area by gender and age showed overall higher incidence of TB disease in; Bakgalagadi dominated catchment area followed by Basarwa and then Mixed, males when compared to females in all dominant tribe's catchment areas, and lower age groups when compared to higher age groups in all dominant tribe's catchment areas. Boxplot of registered tuberculosis cases against age in each dominant tribe's catchment area by gender for each health care facility showed no evidence of clustering of the disparity in cases between the sexes and age by dominant tribe nor health facility (Figure 2). Risk of TB disease and odds of exposure to TB disease in each of the communities and whole of Ghanzi Sub-district population as well as test for significant risk difference using Ghanzi Township community as baseline showed no discernable risk gradient of one community contracting TB disease from another (Table 2).

Treatment matrix for TB patients at the time of admission for all health care facilities was; 123 (5.2%) for those who defaulted on previous treatment and of which none had MDR, 1861 (78.8%) for those on initial treatment and of which 2 (0.001%) had MDR, 353 (0.1%) for those with TB relapse after completing previous treatment and of which 8 (0.02%) had MDR, and 25 (0.01%) for those who have experienced complete treatment failure and of which 6 (0.24%) had MDR. Of all the recorded MDR-TB cases during the study period, 12 (75%) were in Ghanzi Township. Median (minimum, maximum) TB treatment duration for

Ghanzi Sub-district was 184.5 (0, 413) days for extrapulmonary TB and 183.0 (0, 439) days for pulmonary TB. Outcomes of treatment varied to some extent by dominant tribe and gender under each dominant tribe. For all of Ghanzi Sub-district; 1258 (53.3%) patients completed their course of treatment or got cured, 208 (8.8%) defaulted with males more affected than females, 171 (7.2%) died with males more affected than females, 35 (1.5%) experienced treatment failure, and 690 (29.2%) had undocumented treatment outcome (Table 3).

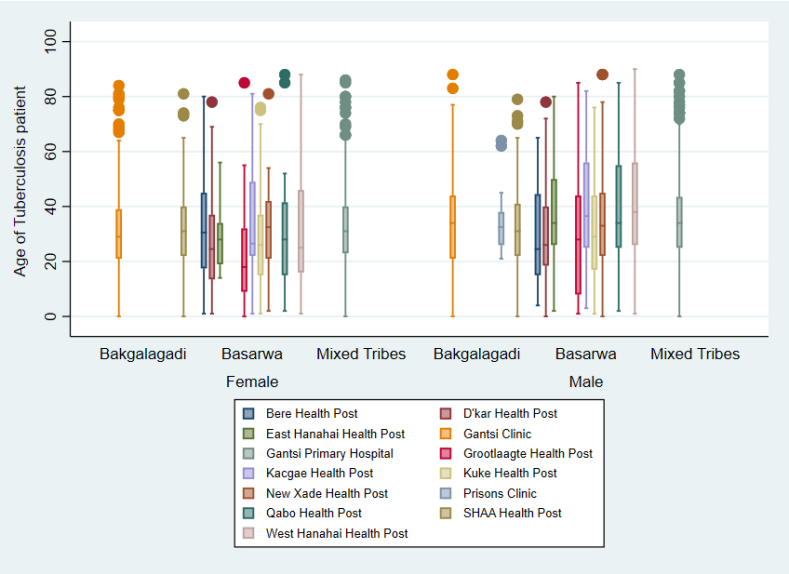

Figure 2: Boxplot of registered tuberculosis cases against age in each dominant tribe by gender for each health care facility in Ghanzi Sub-district.

Table 2: Chi-squared test for equality of proportions of diagnosed tuberculosis cases in each community in the Ghanzi Sub-district (percentage in brackets) to the proportion of diagnosed TB cases in Ghanzi township community as the baseline. Also indicated are the odds of exposure (tuberculosis disease) amongst case-communities (villages within Ghanzi Sub-district) when compared to the control-community of Ghanzi township.

Community	Base Population	Tuberculosis Cases	Odd Ratio (95% CI)	Chi-square Test
Bere Village	778	40 (0.05)	0.482 (0.50 – 0.664)	χ^2 = 20.56; p < 0.001
D'kar Village	1668	156 (0.09)	0.918 (0.772 – 1.090)	χ^2 = 0.95; p = 0.329
East Hanahai Village	559	26 (0.05)	0.434 (0.292 – 0.644)	χ^2 = 17.99; p < 0.001
Grootlaagte Village	1026	139 (0.14)	1.394 (1.158 – 1.678)	χ^2 = 12.36; p < 0.001
Kacgae Village	634	50 (0.08)	0.761 (0.569 – 1.020)	χ^2 = 3.34; p = 0.068
Kuke Village	833	104 (0.12)	1.268 (1.027 – 1.567)	χ^2 = 4.88; p = 0.027
New Xade Village	1464	79 (0.05)	0.507 (0.402 – 0.640)	χ^2 = 33.97; p < 0.001
Qabo Village	762	50 (0.07)	0.625 (0.467 – 0.835)	χ^2 = 10.21; p < 0.001
West Hanahai Village	781	71 (0.09)	0.889 (0.694 – 1.140)	χ^2 = 0.85; p = 0.357
Ghanzi Township	16276	1645 (0.10)	1.00 (0.930 – 1.075)	χ^2 = 0.00; p = 1.000
Ghanzi Sub-district	24781	2362 (0.10)	0.937 (0.877 – 1.001)	χ^2 = 3.69; p = 0.055

Table 3: Frequency distribution, with column percentage in brackets, of tuberculosis treatment outcome by dominant tribes and gender within each dominant tribe in the Ghanzi Sub-district.

Treatment outcome	Bakgalagadi			Basarwa			Mixed Tribes			Total		
	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
Completed or cured	265	334	599	296	312	608	21	30	51	582	676	1,258
	(11.2)	(14.1)	(25.4)	(12.5)	(13.2)	(25.7)	(0.9)	(1.3)	(2.2)	(24.6)	(28.6)	(53.3)
Defaulted	66	98	164	6	16	22	7	15	22	79	129	208
	(2.8)	(4.2)	(6.9)	(0.3)	(0.7)	(0.9)	(0.3)	(0.6)	(0.9)	(3.3)	(5.5)	(8.8)
Died	27	34	61	15	21	36	33	41	74	75	96	171
	(1.1)	(1.4)	(2.6)	(0.6)	(0.9)	(1.5)	(1.4)	(1.7)	(3.1)	(3.2)	(4.1)	(7.2)
Failed	5	6	11	7	3	10	6	8	14	18	17	35
	(0.2)	(0.3)	(0.5)	(0.3)	(0.1)	(0.4)	(0.3)	(0.3)	(0.6)	(0.8)	(0.7)	(1.5)
Missing	45	83	128	20	19	39	245	278	523	310	380	690
	(1.9)	(3.5)	(5.4)	(0.9)	(0.8)	(1.7)	(10.4)	(11.8)	(22.1)	(13.1)	(16.1)	(29.2)
Total	408	555	963	344	371	715	312	372	684	1,064	1,298	2,362
	(17.3)	(23.5)	(40.8)	(14.6)	(15.7)	(30.3)	(13.2)	(15.8)	(29.0)	(45.1)	(55.0)	(100.0)

4. Discussion

We set out to describe the frequency and distribution of TB cases in Ghanzi Sub-district based on existing records to deduce tentative contemporary relevant aetiological factors. Our study found substantial inefficiencies in patient medical history taking, nursing documentation of patient care and management. A critical proportion of TB patients had undocumented HIV status, either because they were not asked or tested for it at time of admission and this likely inadequately informed treatment protocols prescribed. People living with HIV (PLHIV) are estimated to be 18 (15 – 21) times more likely to develop active TB disease than people without TB (WHO, 2020). Early access to antiretroviral therapy (ART), informed by known HIV status at time of admission for TB treatment, is a critical intervention to improve survival of HIV-infected patients with TB (Mfinanga et al., 2014). Lack of integrated therapy for HIV and TB, whereby patients are referred from TB to HIV separate clinics as was the case, instead of a single facility and a single healthcare provider delivering care for both diseases, was the likely cause for gaps in patients HIV medical history taking (Manosuthi et al., 2016).

Missing data was also realized for smear results, treatment outcomes and sputum smear grades in the availed records. Healthcare facilities, except for Ghanzi Primary Hospital, did not have requisite capacity to run alternative test to smear microscopy like chest radiography, skin tests nor TB blood tests. Therefore, either diagnosis of TB in patients with missing (41.2%) or negative (12.1%) smear results was diagnosed clinically leading to empiric treatment or their sputum samples would have been sent elsewhere for testing, with test results communicated back remotely to effect treatment but forgotten to be documented. The realized 12.1% negative smear test results may have been indicative of high level of HIV comorbidity amongst cases and may also have been driven by young age at infection evidenced by a positively skewed distribution of TB cases by age group. HIV-positive patients and children are more likely to have clinical disease when the bacillary burden is still low, resulting in smear-negative results or pauci-bacillary microscopy (Goto et al., 2003). Omission on sputum smear grading results, as an indicator for bacilliary load, denied healthcare professionals and patient caregivers of knowledge on levels of infectiousness of patients to inform implementation of preventative measures like isolation and quarantining, at least in the initial phase of treatment. Patients with higher bacilliary load could have a higher chance of infection transmission and development of active TB among contacts than those with lower grading (Katz and Vaught, 2017; Lohmann et al., 2012). Of all the recorded patient sputum smear gradings, approximately 62% had a 3^{+} grading indicating higher level of infectiousness. Additionally, drug resistance through plateauing of subsequent bacilliary load measurements and remission through attenuation of subsequent bacilliary load measurements could have been read from smear grading results.

Overall, where the sputum smear tests were performed and recorded it seemed to have been conducted satisfactorily enabling diagnosis of approximately 80% true TB positive cases. This is well above the reported smear microscopy sensitivity of 22 - 43% for a single smear microscopy, with a mean incremental yield in sensitivity of 9% with a second sample and 4% with a third sample, totaling about 56% maximum sensitivity. However, such an exceptional performance of the smear test in a situation where pulmonary TB is overrepresented (85.3%) may point to high likelihood of comorbidity with HIV as it has been reported previously that 20-60% of HIV negative pulmonary TB cases test negative on smear test leading to lower sensitivity (Shin and Seung, 2013).

Observed gender difference in TB incidence may be explained in part by behavioral differences through contact patterns contributing to disparities in tuberculosis burden by increasing incidence among men (Horton et al., 2020). Notable risk factors of developing TB such as alcohol consumption and smoking are mainly practiced among men than among women (Narasimhan et al., 2013). Higher overall TB incidence amongst Bakgalagadi dominated areas when compared to Basarwa and Mixed dominated areas may be due to disparity in socio-economic elements that negatively affect TB. Bakgalagadi dominated in more developed areas with higher population densities when compared to dispersed settlements dominated by Basarwa. High population density has potential to precipitate inadequate housing with overcrowding and poor ventilation, which directly affects TB exposure, transmission, incidence, and drug resistance (Lee et al., 2022). Lack of notable TB incidence clustering and transmission gradient across Ghanzi Sub-district may have been indicative of high population mobility owing to improved transport connectivity between villages and settlements, leading to probable equitable seeding and local transmission of TB infection (Hargreaves et al., 2011). This high mobility is likely evidenced by the noted high movement, 22.7%, of all TB patients between health care facilities.

Realized TB treatment success rate of 53.3% for cases with complete records is below the global rate of 85% for new cases of TB and 76% for TB patients living with HIV (WHO, 2020). Moreover, its much lower than the estimated 78.9% success rate in Africa (Chaves-Torres et al., 2019). Median treatment duration was within the prescribed 6 months duration for the drug-susceptible TB (WHO, 2022b). Lower scales of treatment duration, just like lower treatment success rate, were likely occasioned by loss to follow up due to either death, patients transfer between health care facilities in the absence of continued records or default on treatment. Higher scales of treatment duration are likely due to MDR patients staying longer on treatment to improve the odds of cure and poor adherence to treatment leading to repeated treatments (Winston and Mitruka, 2012; Dooley et al., 2011).

5. Conclusion

There is a significant deficiency in completing patient records across Ghanzi Sub-district to facilitate evidence-based treatment approach and this could be due to several factors that includes sample referral for testing, excessive patient movement between health care facilities leading to loss to follow up and an unintegrated therapy for HIV and TB.

Ethics and Informed Consent

Ethics approval was obtained from the Ministry of Health, Health Research & Development Division Ethics Committee, Gaborone, Botswana [Ref: PPME 13/18/1 PS Vol. V (237)].

Conflict of Interest

There is no conflict of interest to declare.

Author Contribution

In this study N. Babayani performed statistical analysis on the data and drafted the initial manuscript version. V. Pagiwa sourced the data and revised the manuscript for important intellectual content. Both authors have approved the final version of the manuscript for publication.

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