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SOCIO-ECONOMIC AND DEMOGRAPHIC CORRELATES OF TUBERCULOSIS-RELATED MORTALITY IN HOMA BAY COUNTY, KENYA
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SOCIO-ECONOMIC AND DEMOGRAPHIC CORRELATES OF TUBERCULOSIS-RELATED MORTALITY IN HOMA BAY COUNTY, KENYA

V. K. Rono and C. O. Migwambo

ABSTRACT

***Background*: In Kenya, tuberculosis (TB) incidence, prevalence and related mortality rates remain high despite the reduction in global rates. The impact is reduced individual work productivity and dispossessing households of the wealth endowments. Locally, Homa Bay County records one of the highest numbers of TB-related deaths despite provision of a standard and effective package of care at no cost in public hospitals in all the 47 counties in Kenya. The reason for this disparity is yet to be explored.**

***Objective:* The aim of this study was to outline and analyse the socio-economic and demographic covariates influencing TB-related mortality in Homa Bay County.**

***Design*: A probit model was used to determine the correlates and determinants of TB-related mortality.**

***Results*: The main risk factor for TB-related death identified in Homa Bay County was TB/Human Immunodeficiency Virus (HIV) co- infection. Severe malnutrition, being male and advanced age were also key predictors of mortality.**

***Conclusion*: It is recommended that patients at high risk of death should be identified and provided with a differentiated package of care, including closer follow-up and monitoring to reduce TB-related deaths in Homa Bay County. Further, in such populations with high HIV prevalence, TB screening efforts should be intensified with early diagnosis and treatment for better outcomes.**

INTRODUCTION

The prevalence and incidence of tuberculosis (TB)-related mortality is a universal health problem that causes more than 10 million deaths each year. This is despite the fact that with a timely diagnosis and correct treatment, TB is curable[1]. Progress in reducing TB mortality in most LMICs has not been rapid enough to achieve global targets or close persistent treatment and prevention gaps[2]. Further, TB treatment at advanced stages is costly and therefore reduces a household's income.

In African countries with endemic TB prevalence, Kenya ranks fifth after the Democratic Republic of Congo, Ethiopia, Nigeria and South Africa[3]. The mortality ratio in Kenya stands at 60 per 100,000 people and has been shown to be higher than in other African countries like Nigeria, Rwanda, Tanzania and Uganda. Locally, Homa Bay County in Kenya had one of the highest TB-related mortality rates based on a survey carried out in 2016[4]. This county has a perpetually high HIV and TB prevalence necessitating the need for development of policy guidelines on optimal resource allocation for clinical management.

TB/HIV co-infection is the major cause of morbidity and mortality in low- and middle-income countries[5]. TB mortality among HIV-positive individuals is highest in the African region compared to other regions as shown by a World Health Organization (WHO) report (Table 1). Overall, TB mortality in males less than 14 years of age was slightly higher (32.0%) than that of females of the same age group.

Table 1
TB Mortality among HIV-Negative and Positive Individuals

(1a) TB Mortality among HIV Negative Individuals					
WHO Region	**Total**	**TB Mortality Male (0-14 years)**	**TB Mortality Female (0-14 years)**	**TB Mortality Male (>14 years)**	**TB Mortality Female (>14 years)**
Africa	417,000	32,000	27,000	231,000	126,000
Americas	17,000	2,500	2,100	8,300	4,100
Eastern Mediterranean	82,000	7,100	5700	39,000	30,000
Europe	26,000	2,600	2,2,000	16,000	5,500
South-East Asia	652,000	48,000	39,000	375,000	191,000
Western Pacific	103,000	17,000	14,000	49,000	22,000
Global Total	**1,297,000**	**109,200**	**87,800**	**718,300**	**378,600**
(1b) TB Mortality among HIV Positive Individuals					
Africa	320,000	23,000	20,000	177,000	100,000
Americas	6,200	1,000	1	2,900	1,500
Eastern Mediterranean	3,000	0	0	1,400	1,100
Europe	5,100	0	0.39	3,000	1,200
South-East Asia	35,000	2,400	0	20,000	9,900
Western Pacific	5,000	930	1	2,200	1,000
Global Total	**374,000**	**28,000**	**24,000**	**207,000**	**115,000**

In Brazil, studies show that TB/HIV-co-infection is an important predictor of TB mortality and that extra-pulmonary TB and treatment dropout were positive risk factors of TB mortality (6). A higher proportion of early deaths occurred in patients with smear-positive pulmonary tuberculosis and extra-pulmonary tuberculosis and risk was further associated with increasing age in Malawi[7]. However, among individuals without HIV/AIDS, mortality was associated with older age, especially being older than 50 years, mixed clinical forms, and treatment dropout. Furthermore, a study in Ethiopia showed that the type of occupation, severity of disease and residing in rural areas seemed to have a significant association with increased TB mortality[8].

Possible factors contributing to high TB-related mortality in Homa Bay County have been scarcely explored in empirical work and subsequently, efforts to reduce mortality tend to be ineffective due to lack of evidence-based policies. In addition, the impact of TB/HIV co-infection on mortality has been scarcely explored in this county despite high prevalence of HIV[9]. Therefore, the aim of this study was to analyse the factors contributing to high mortality rates in Homa Bay County and to make policy recommendations towards reducing TB mortality in this county and nationally.

METHODOLOGY

Source and Data Measurements: The data used was drawn from treatment facilities in Homa Bay County on reported cases of TB between 2013 and 2016. It was obtained from records of the TIBU initiative data system spearheaded by the National Tuberculosis, Leprosy and Lung Disease Program in Kenya. The data consisted of demographic characteristics such as age of the patient, sex, weight, height, body mass index, and residence as well as their HIV status. Information on the treatment outcome and type of TB was also available. During analysis, the sample was further stratified by sex to establish existence of any heterogeneity within the sub-samples.

Theoretical framework: It was assumed that a household maximizes a utility function given in Equation (i)

$$U = f(x_1, x_2, x_3) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (i)$$

Where:

U = the household utility,

x_1 = the consumption goods that yields utility to an individual but has no direct effect on the health status of an individual,

x_2 = a health related good or behaviour that yields utility to an individual and also affects their health like smoking or exercises

x_3 = home produced goods in this case health.

Further, the household maximized this utility function subject to a budget constraint, time constraint and health production function. The budget constraint was given by;

$$PC = wH \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (ii)$$

Where;

P = a vector of prices of various goods,

C = a vector of goods,

w = the wage rate

H = the hours worked.

Time constraint was given by; $T = H + L$.

Where;

T = the total is time available

L = leisure.

Expressing H in terms of T and L yields the following;

$$H = T - L \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (iii)$$

Replacing equation (iii) into (ii) yields;

$$PC = w(T - L) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (iv)$$

Equation (iv) gave a combination of the budget and time constraint. Solving equation (*iv*) generated the reduced form demand function for health;

$$D_h = h(x_e, x_p, x_d, x_n, p) \ldots\ldots\ldots\ldots\ldots\ldots\ (v)$$

Where;

D_h = the demand for health services in respect to TB treatment,

x_p = the predisposing factors such as age, occupation, income, place of residence and marital status,

x_e = education.

x_n = the characteristic of the health system as well as the enabling factors like accessibility and quality of the services offered,

p = the price of services.

Empirical modelling: A probit model was used to investigate the socio-economic determinants of TB mortality in Homabay County. The following equation was used:

$$y_i = X_i\beta + \varepsilon_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (i)$$

Where;

y_i = TB mortality which was dichotomous; equal to 1 if reported death is due to TB, 0 otherwise.

X_i = vector of independent variables such as age (in years), gender, occupation, educational status, religion, marital status, residence, TB type, previous history of TB, behavioural factors, type of health facility and the calendar year TB mortality was reported.

β = vector of parameters to be estimated

ε = was the error term

We assumed that $\varepsilon_i \approx N(0,\sigma^2)$ to define the binary response model by transforming $X\beta$ into a probability such that;

$$prob(y_i = 1) = F(X_i\beta) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (ii)$$

Choosing F to be the standard normal gave the probit model as

$$prob(y_i = 1) = \Phi(X_i\beta) = \int_{-\infty}^{X_i} \frac{1}{\sqrt{2\pi}} \exp\left(\frac{-z^2}{2}\right) dz \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (iii)$$

The standard normal transformation $\Phi(\bullet)$ constrained the probability to lie between 0 and 1. In order to estimate the above model, we used the maximum likelihood function given as

$$L = \prod_{i=1}^{m} \Phi(X_i\beta)^{y_i}[1-\Phi(X_i\beta)]^{1-y_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (iv)$$

It was however not possible to estimate equation (v) and thus we linearized to obtain the log-likelihood function for ease of estimation as;

$$Ln = \sum_i \{y_i.\ln[\Phi(X_i\beta)] + (1-y_i)\ln[1-\Phi(X_i\beta)]\} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (v)$$

We then sought $\hat{\beta}$ that maximized the above log likelihood function. In the probit model we calculated the derivatives of the probability with respect to a specific independent variable say X_k in the set of X variables by;

$$\frac{\partial E(y)}{\partial X_k} = \phi(X\beta)B_k \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (vi)$$

$\phi(z)$ Is the standard normal density such that $\phi(z) = \frac{1}{\sqrt{2\pi}} \exp(-\frac{1}{2}z^2)$ .... (vii)

In order to interpret both the sign and the magnitude we estimated the marginal effects.

Ethical approval: This study did not require prior ethical approval since no human participants or animal subjects were directly involved. The data was abstracted from existing hospital records and any possible personal identifiers of the patients omitted from this report to ensure privacy.

RESULTS AND DISCUSSION

Data Characteristics: By locality, 12.6% of the patients were from Homa Bay Town, 9.4% from Kabondo, 14.1% from Kasipul, 11.4% from Mbita, 12.6% from Ndhiwa, 20.2% from Rachuonyo, 10.6% from Rangwe and 9.02% from Suba (Table 2). 12.3% of the patients died with mortality among males (13.7%) being slightly higher than in females (10.6%). 9.2% of the patients were less than 15 years of age, 35.6% were between 15 and 30 years, 33.8% were between 31 and 45 years with only 21.4% being more than 45 years of age (Table 2). Further, 92.2% of the sample patients were newly registered TB patients, 5.6% were cases of relapse and 2.1% were failure cases. 35.8% had their sputum-smear test negative with 2.5% being positive while the majority (61.5%) did not have a sputum-smear test done (Table 2).

Table 2

Data Characteristics

Variable		Female Sample (N=3261)				Male Sample (N=3837)				All Sample (N=7098)			
		Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
TB Treatment Outcome	Died	0.106	0.308	0	1	0.137	0.344	0	1	0.123	0.328	0	1
Region	Kabondo	0.094	0.292	0	1	0.094	0.292	0	1	0.0944	0.292	0	1
	Kasipul	0.143	0.35	0	1	0.139	0.346	0	1	0.141	0.348	0	1
	Mbita	0.121	0.326	0	1	0.108	0.31	0	1	0.114	0.317	0	1
	Ndhiwa	0.132	0.339	0	1	0.121	0.326	0	1	0.126	0.332	0	1
	Rachuonyo	0.19	0.392	0	1	0.213	0.41	0	1	0.202	0.402	0	1
	Rangwe	0.107	0.309	0	1	0.106	0.308	0	1	0.106	0.308	0	1
	Suba	0.091	0.287	0	1	0.09	0.286	0	1	0.0902	0.286	0	1
HIV Status	HIV Positive	0.680	0.467	0	1	0.655	0.475	0	1	0.667	0.471	0	1
TB type	Pulmonary TB	0.208	.406	0	1	0.197	0.400	0	1	0.202	0.401	0	1
Sputum Smear Test	1	0.335	0.472	0	1	0.379	0.485	0	1	0.359	0.48	0	1
	2	0.642	0.479	0	1	0.594	0.491	0	1	0.616	0.486	0	1
Type of Facility	Private	0.197	0.397	0	1	0.19	0.392	0	1	0.193	0.395	0	1
	Other	0.001	0.030	0	1	0.007	0.085	0	1	0.004	0.066	0	1
Patient Type	Relapse	0.052	0.223	0	1	0.059	0.236	0	1	0.056	0.23	0	1
	Failure	0.021	0.143	0	1	0.022	0.145	0	1	0.021	0.144	0	1
Age Category	Between 15 & 30 years	0.416	0.493	0	1	0.305	0.461	0	1	0.356	0.479	0	1
	Between 31 & 45 years	0.285	0.451	0	1	0.383	0.486	0	1	0.338	0.473	0	1
	<45 years	0.194	0.396	0	1	0.231	0.421	0	1	0.214	0.41	0	1
Treatment Date	2014	0.444	0.497	0	1	0.396	0.489	0	1	0.418	0.493	0	1
	2015	0.282	0.45	0	1	0.308	0.462	0	1	0.296	0.457	0	1
	2016	0.257	0.437	0	1	0.276	0.447	0	1	0.267	0.442	0	1
Registration Date	2015	0.291	0.454	0	1	0.319	0.466	0	1	0.306	0.461	0	1
	2016	0.269	0.443	0	1	0.286	0.452	0	1	0.278	0.448	0	1
Nutrition	Moderate	0.246	0.431	0	1	0.302	0.459	0	1	0.276	0.447	0	1
	Normal	0.390	0.488	0	1	0.392	0.488	0	1	0.391	0.488	0	1
	Over	0.055	0.228	0	1	0.022	0.147	0	1	0.037	0.189	0	1
	Obese	0.111	0.314	0	1	0.105	0.306	0	1	0.107	0.31	0	1

For HIV status, 33.3% were HIV-negative while 66.6% were HIV-positive. Of those who tested positive for HIV, 68.0% were females while 65.5% were males. 20.2% of the sample population had Pulmonary Tuberculosis (PTB) while the remaining had extra-pulmonary TB, of which 20.8% were females and 19.7% males (Table 2). On nutrition, 39.1% were classified as normal and constituted the majority in the sample, 18.9% had severe malnutrition while 10.7% were obese.

Tuberculosis mortality across socio-economic profiles: A large proportion of the reported deaths were in public facilities (77.9%) while 22.1% occurred in private facilities with more deaths (91.0%) being among the newly-diagnosed cases of TB (Figure 1). Majority of the reported deaths were in patients classified as severely malnourished (29.1%) or moderately malnourished (26.3%) while a third (30.3%) were those with normal nutritional status. 1.5% of them were overweight while 12.7% of the patients who died of TB were obese. Those who were HIV positive had the highest incidence of TB mortality at 76.1% while 23.9% of the reported deaths were HIV negative. 72.2 % of TB mortality was associated with PTB while the incidence of Extra-PTB was associated with 27.8% of reported deaths. Mortality due to TB were highest among males (60.4%) compared to females (39.6%), (Figure 1).

Determinants of tuberculosis mortality: The coefficient of HIV status (i.e. being HIV positive) among TB patients was 0.198 implying that for every 10 who were HIV positive, 2 of them were likely to succumb to TB (Table 3). This is similar to findings in Zimbabwe[10] where HIV/TB co-infection was significantly associated with TB-related mortality and suggests the need for a differentiated package of care and closer follow-up and monitoring among these patients.

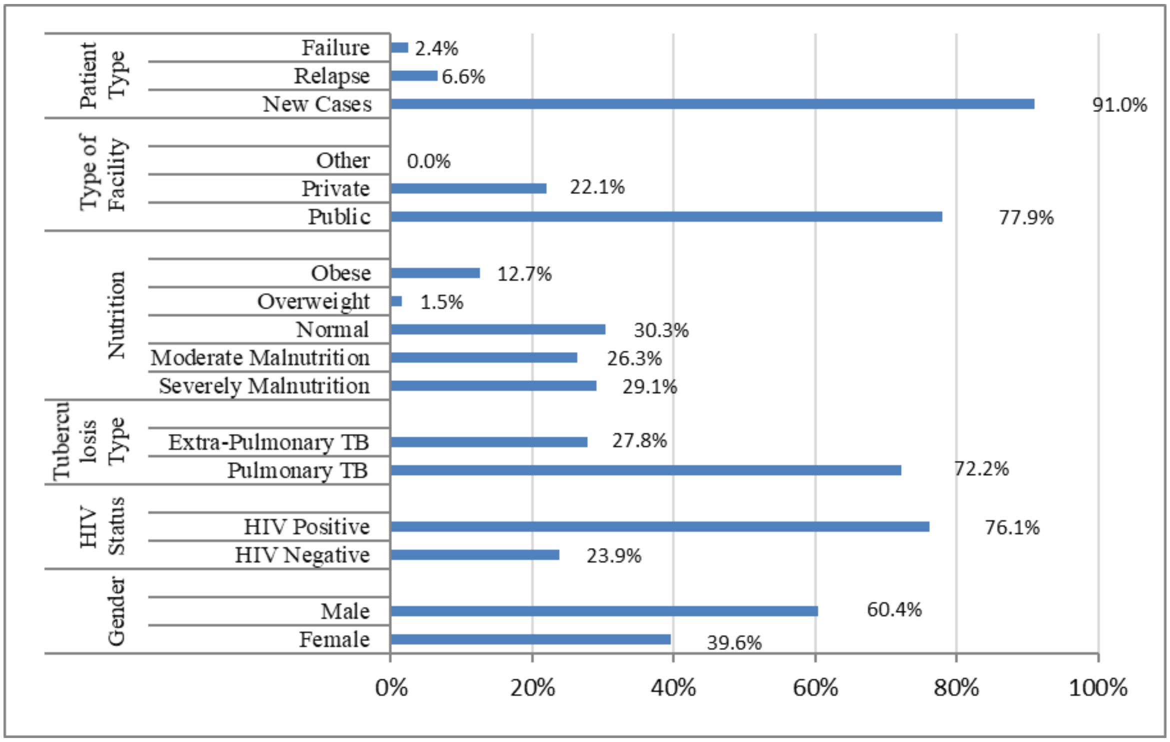

Figure 1: Tuberculosis mortality among patients across different socio-economic profiles

The type of health facility, whether public or privately owned, was not a predictor of TB mortality in Homa Bay County (Table 3) despite high prevalence of TB mortality in public hospitals described above (Figure 1). This could be attributed to higher patient numbers in public due to provision of TB medication at no cost in public healthcare facilities. Nutritional status was also an important predictor of TB mortality with severely malnourished patients more likely to die compared to those with normal nutritional status. This finding is supported by a study in Tanzania which showed that micronutrient supplementation improved outcome of TB patients[11].

Being male was associated with increased risk of TB-related mortality (Table 3). This is similar to findings in the United States[12] and could be attributed to poor medication adherence among this gender and lifestyle factors such as smoking. Lastly, older individuals, especially those older than 45 years, were more likely to die of TB compared to younger individuals. Older age (>45 years) was similarly identified as a major risk factor for mortality among TB patients in rural India[13] and this could be attributed to weakening of immune response with increasing age.

Table 3: *Modelling of Tuberculosis mortality in Homa Bay County*

	Variables	Full Sample Linear Probability Model	Full-Sample Probit Regression Model	Female Probit Regression Model	Males Probit Regression Model
Constant	Intercept	-0.210** (-2.55)	-6.692 (-0.05)	-5.587 (-0.05)	-6.662 (-0.05)
Gender	Male	0.0386*** (4.95)	0.207*** (4.79)	-	-
HIV Status	HIV Positive	0.0266*** (3.10)	0.198*** (3.90)	0.162** (2.03)	0.221*** (3.32)
Type of TB	Pulmonary TB	-0.0158 (-1.52)	-0.0512 (-1.02)	-0.0177 (-0.23)	-0.0776 (-1.17)
Sputum smear test	Negative	-0.0742*** (-3.02)	-0.770*** (-5.40)	-0.722*** (-3.19)	-0.799*** (-4.32)
	Not Determined	0.0878*** (3.57)	0.383*** (2.87)	0.278 (1.31)	0.463*** (2.68)
Type of facility	Public Facility	0.146** (2.48)	4.445 (0.03)	3.431 (0.03)	4.550 (0.03)
	Private Facility	0.146** (2.45)	4.429 (0.03)	3.445 (0.03)	4.507 (0.03)
Patient type	Relapse	0.0282* (1.69)	0.149* (1.68)	0.174 (1.25)	0.135 (1.18)
	Failure and Treatment	0.0216 (0.80)	0.133 (0.93)	-0.0197 (-0.09)	0.264 (1.42)
Age	Between 15 & 30 Years	0.0783*** (5.16)	0.379*** (4.44)	0.284** (2.34)	0.480*** (3.97)
	Between 31 & 45 Years	0.0837*** (5.41)	0.426*** (5.00)	0.340*** (2.70)	0.525*** (4.45)
	<45 Years	0.123*** (7.67)	0.638*** (7.34)	0.513*** (4.00)	0.759*** (6.32)
Treatment date	2014	-0.0548 (-1.00)	-0.306 (-0.99)	-0.407 (-0.83)	-0.302 (-0.73)
	2015	-0.00397 (-0.09)	0.0132 (0.05)	0.00322 (0.01)	-0.0118 (-0.03)
	2016	-0.00514 (-0.13)	0.0123 (0.06)	0.155 (0.52)	-0.116 (-0.38)
Registration date	2015	0.00108 (0.04)	-0.00241 (-0.02)	-0.0815 (-0.35)	0.0413 (0.22)
	2016	-0.0113 (-0.24)	-0.0527 (-0.21)	-0.0406 (-0.11)	-0.0919 (-0.26)
Nutrition	Severe Malnutrition	0.0934*** (8.35)	0.468*** (8.09)	0.533*** (6.19)	0.424*** (5.38)
	Moderate Malnutrition	0.0242** (2.54)	0.141** (2.57)	0.174** (2.00)	0.120* (1.68)
	Overweight	-0.0477** (-2.29)	-0.395*** (-2.64)	-0.454** (-2.21)	-0.289 (-1.30)
	Obese	0.0557*** (3.97)	0.306*** (4.08)	0.232** (1.99)	0.368*** (3.72)
Region	Kabondo	0.0128 (0.76)	0.0950 (0.97)	0.135 (0.89)	0.0746 (0.57)
	Kasipul	0.0337* (1.87)	0.196* (1.92)	0.392** (2.54)	0.0528 (0.39)
	Mbita	0.0152 (0.93)	0.119 (1.23)	0.173 (1.16)	0.0991 (0.78)
	Ndhiwa	-0.00228 (-0.13)	-0.0180 (-0.17)	-0.0324 (-0.20)	0.0100 (0.07)
	Rachuonyo	0.0472*** (2.83)	0.302*** (3.16)	0.437*** (3.02)	0.183 (1.41)
	Rangwe	0.0203 (1.30)	0.145 (1.60)	0.200 (1.42)	0.112 (0.94)
	Suba	0.0236 (1.35)	0.161 (1.59)	0.167 (1.05)	0.147 (1.11)
	N	6901	6901	3162	3739
	R^2	0.082			
	Adj. R^2	0.078			

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p <$

CONCLUSION AND RECOMMENDATIONS

HIV/TB coinfection was the most distinguishing determinant of mortality attributed to the existing high prevalence rate of HIV in Homa Bay County. HIV testing for all presumptive TB patients is therefore recommended. Likewise, intensive screening of HIV-infected patients for early diagnosis and treatment of TB in this setting would improve outcomes. Nutritional status was also a key predictor of TB mortality and thus, proper nutrition should be encouraged among patients on TB therapy. Being male and advanced age were also identified as risk factors for increased mortality and a differentiated package of care, including more frequent follow-up appointments and clinical monitoring would improve health outcomes in these patients.

A limitation of this study is the application of a retrospective approach making it difficult to establish a temporal relationship thus, further research using a prospective design is recommended to provide evidence of causality.

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