DOI 10.1186/s12887-018-1003-4

RESEARCH ARTICLE

Marbán-Castro et al. BMC Pediatrics (2018) 18:56



Open Access

BCG vaccination in southern rural Mozambique: an overview of coverage and its determinants based on data from the demographic and health surveillance system in the district of Manhiça

Elena Marbán-Castro¹, Charfudin Sacoor², Ariel Nhacolo², Orvalho Augusto², Edgar Jamisse², Elisa López-Varela^{1,2}, Aina Casellas¹, John J. Aponte^{1,2}, Quique Bassat^{1,2,3}, Betuel Sigauque², Eusebio Macete² and Alberto L. Garcia-Basteiro^{1,2,4*}

Abstract

Background: Over the past four decades, the World Health Organization established the Expanded Programme on Immunization (EPI) to foster universal access to all relevant vaccines for all children at risk. The success of this program has been undeniable, but requires periodic monitoring to ensure that coverage rates remain high. The aim of this study was to measure the BCG vaccination coverage in Manhiça district, a high TB burden rural area of Southern Mozambique and to investigate factors that may be associated with BCG vaccination.

Methods: We used data from the Health and Demographic Surveillance System (HDSS) run by the Manhiça Health Research Centre (CISM) in the district of Manhiça. A questionnaire was added in the annual HDSS round visits to retrospectively collect the vaccination history of children under the age of 3 years. Vaccinations are registered in the National Health Cards which are universally distributed at birth. This information was collected for children born from 2011 to 2014. Data on whether a child was vaccinated for BCG were collected from these National Health Cards and/or BCG scar assessment.

Results: A total of 10,875 number of children were eligible for the study and 7903 presented the health card. BCG coverage was 97.4% for children holding a health card. A BCG-compatible scar was observed in 99.0% of all children and in 99.6% of children with recorded BCG in the card. A total of 93.4% of children had been vaccinated with BCG within their first 28 days of life. None of the factors analysed were found to be associated with lack of BCG vaccination except for living in the municipality of Maluana compared to living in the municipality of Manhiça; (OR = 1.89, 95% CI: 1.18-3.00). Coverage for other EPI vaccines during the first year of life was similarly high, but decreased for subsequent doses.

Conclusions: BCG coverage is high and timely administered. Almost all vaccinated infants develop scar, which is a useful proxy for monitoring BCG vaccine implementation.

Keywords: BCG vaccine, Tuberculosis, Pediatrics, Expanded programme on immunization, Epidemiology, Mozambique

¹ISGloba⁻, Barcelona Ctr. Int. Health Res. (CRESIB), Hospital Clínic-Universitat de Barcelona, C/Rosselló 132, 08036 Barcelona, Spain

²Centro de Investigação em Saúde da Manhiça (CISM), Rua 12, Vila de

Manhiça, CP 1929 Maputo, Mozambique

Full list of author information is available at the end of the article



© The Author(s). 2018 **Open Access** This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The Creative Commons Public Domain Dedication waiver (http://creativecommons.org/publicdomain/zero/1.0/) applies to the data made available in this article, unless otherwise stated.

^{*} Correspondence: alberto.garcia-basteiro@isglobal.org; alberto.garciabasteiro@manhica.net

Background

Tuberculosis (TB) remains a global public health concern, responsible for an estimated 1.8 million deaths in 2015. It stands as the leading cause of death by an infectious agent worldwide [1]. The only available vaccine to fight TB is the Bacille Calmette-Guérin (BCG) vaccine, first administered in 1921 and, probably the most widely used vaccine in the world [2, 3]. Although the efficacy of BCG against pulmonary TB has been questioned [4], it remains an essential approach for prevention of the most severe forms of TB in children (with an estimated efficacy against miliary TB and TB meningitis of 77 and 73% respectively) [5, 6]. It also reduces infection [7] and all-cause mortality through non-specific effects of the immune system [8]. A recent study has shown a longlasting protection of BCG, being more cost-effective than previously thought [9]. Moreover, non TB beneficial effects have been reported such as protection against other causes of death, or reduced risk of death from pneumonia and malaria (studies from African and Asian low-income countries) [2, 10, 11]. Administered at birth, BCG reduces neonatal mortality by 48% in low-birth weight infants [12]. An added importance of BCG is its proximity to the delivery event and thus being the entry point to EPI and other health packages [12].

The WHO recommends vaccinating all newborns in endemic areas with BCG at birth, except in cases of positive or suspicion of HIV infection [4]. In settings where HIV status cannot be discarded at the time of vaccination, for example, infants born to HIV-positive mothers with unknown status and lacking suggestive symptoms, BCG should be given after considering local epidemiology.

The development of a scar secondary to BCG vaccination is a good indicator of vaccination response, associated with reduction of childhood mortality [5, 11, 13], but there are other factors involved in the lack of the immune response, such as cold chain management. The most widely used strategies to assess BCG vaccination include the verification of its administration through vaccination cards [2, 14-19] and the direct observation of a BCG-compatible scar [2, 14, 20, 21]. Studies have reported many risk factors associated with no vaccination, including female gender, great number of siblings, lower mother's education, low knowledge of vaccine schedule, single or divorced marital status, poor wealth index and low density of health workers, among others [14, 17, 21-24].

Mozambique is one of the countries with highest TB incidence and lowest TB case detection rates in the world [1, 25]. A recent study showed that TB is associated with 6.5% of all deaths in a rural district in the south of the country [26]. TB control strategies are

based on improving and enhancing access to diagnosis treatment, and prevention through vaccination or preventive treatment. The Mozambican Expanded Programme on Immunization (EPI) was first introduced in 1979 with a commitment of reducing infant mortality and morbidity by immunization [27]. Nevertheless, constraints related to its weak performance have been idenat several levels: poor programme tified data management, inadequate logistic, insufficient financial resources and cold chain management, among others [27]. A complete immunization program for the first year of life includes BCG and an Oral Polio Vaccine (OPV) at birth, three more doses of OPV and three doses of pentavalent vaccine (Diphtheria, Tetanus, Pertussis, Hepatitis B, Haemophilus influenzae type b) at 6, 10 and 14 weeks, and a measles vaccine at month 9 respectively. More recently, the conjugate vaccines against pneumococcal disease (2009) and against rotavirus (2011) have also been added to this schedule. Vaccines are administered free of charge and at several peripheral health care centres, widening the possibilities of being vaccinated.

The WHO (2015) reports an official estimated BCG coverage for Mozambique of 95% based on data from the Demographic and Health Survey [28]. However, the reliability of these official estimates has been questioned because BCG vaccination coverage differs from institution to institution and estimates have been reported above 100% [18, 29]. Moreover, critical BCG vaccine shortages have been reported between 2013 to 2015 in many countries [30]. Thus, this study was conducted to measure BCG vaccination coverage among children below 36 months of age, through BCG recorded in national health cards and by BCG scar assessment. As secondary objectives, we aimed to a) analyse BCG timeliness, in order to evaluate whether the vaccine was given in the right time period b) compare the coverage of BCG to other vaccines and c) identify the sociodemographic factors that might be associated with lack of BCG vaccination.

Methods

Study design and setting

The study was conducted in the district of Manhiça, Maputo Province, a rural area of Southern Mozambique, where the Manhiça Health Research Centre (CISM) runs a Health and Demographic Surveillance System (HDSS) since its foundation in 1996 [31]. It is a high TB and HIV burden area [32, 33]. In 2014, the HDSS was expanded to cover the entire district, an area of 2380 km² that comprises around 38,000 enumerated and geopositioned households, and about 178,000 individuals. Compared to the official census, DHS, health service data and civil registrations, the HDSS is considered a gold standard tool for population indicators and crossnational comparisons [1, 34].

In Mozambique, where high pediatric TB rates and low case detection rates have been reported [35, 36], children receive a national health card (also called "vaccination card") at birth or in their first contact with the health system, where immunization, anthropometric and basic health data are registered. All children born in the district of Manhiça participate in the HDSS.

Design / participants

In every HDSS round, demographic information about births, deaths and migration is updated. This is a cross-sectional study performed at the time of the HDSS census rounds of 2014 and 2015, which included a specific form to collect information about vaccination status. In each round, information was collected for children who were up to 3 years of age, thus in the round of 2014, children born in 2011, 2012 and 2013 were evaluated; and from 2012 onwards for the round of 2015. Information for all children who were less than 36 months of age at the HDSS census rounds was selected. Health cards, whenever available, were evaluated by the field worker, who collected information about administration of all vaccines. In order to estimate BCG and other EPI vaccines coverage through the assessment of vaccination card, we only included children who presented the card at the time of the interview; in order to assess BCG vaccination coverage through the presence of scar, we included all children observed at the visits.

Data collection and analysis

Data cleaning, prior to data analysis, included deletion of duplicated records or incomplete variables. Duplicated observations occurred because the questionnaire was administered to every child irrespective of having or not responded to previous rounds. This allowed to have the most updated information for missed children in previous visits and newborns. When duplicate observations were present, those observations with the most complete data for all variables were preserved.

BCG vaccination coverage (VC) was defined as the proportion of children with recorded BCG vaccine in their health card divided among children whose health card was assessed and readable. VC was calculated as a proportion of children receiving a BCG or other EPI vaccines divided by the total number of eligible children (those who should have received it according to their age at the time of the visit and whose health card was assessed, readable and without missing dates). VC was calculated as a proportion, with 95% confidence intervals (CI). Information about children included variables such as sex, number of siblings, season of birth and area of residence. Mothers' data was obtained from other HDSS questionnaires in which information about family members is routinely collected, including religion, education or marital status. Variables at household level, such as wealth index and distance to nearest health centre were also included. The variable wealth index was estimated using principal component analysis (PCA) with variables related to the household assets following the recommendations of Vyas et al. [37].

To measure the coverage of BCG through scar assessment, the number of children who presented a BCG scar was divided by the total number of children assessed for scarring. The coverage was also measured among children with and without health cards and among children with BCG according to their health card. Delay in BCG administration was defined as a child receiving BCG vaccine after the first 28 days of life.

In the descriptive analysis absolute and relative frequencies were calculated. The description included qualitative variables and quantitative variables categorized according to the objective of the study.

Every variable which a priori seemed to be potentially associated with absence of BCG vaccination in the card was tabulated against BCG administration. Odds Ratios with a 95% CI and *p*-values were calculated. A stepwise procedure was carried out in order to build a multivariate logistic regression model using those variables with p-values < 0.15 in the univariate analysis.

The analysis was conducted using Stata 13 (StataCorp LP, College Station, TX, USA). Graphs and tables were produced with Excel (Microsoft Office 2016, USA).

Results

Population and socio-demographic characteristics

According to CISM's HDSS database, 11,537 children were born between 1st January 2011 and 31st December 2014 in the district of Manhiça. From the 10,875 eligible children (born in that period and under 36 months at the time of annual visits), 9512 children were visited. Around 72.9% (7903/10,875) of children presented a health card to the field workers for transcription of the information on vaccination. Of 2972 children whose card was not available, 48.9% of cases declared the reason was that the adult responding to the HDSS questions could not find the card and, in almost a quarter, 23.1%, no reason was recorded.

BCG and other vaccines coverage

Among children with a health card, information about BCG vaccination (either yes or no) was recorded in

98.9% of the cases and, from those, 91.9% were present at the time of the interview allowing the evaluation of their arm to see the scar post BCG vaccination (see Fig. 1). Regardless of having the vaccination card, 8298 children were evaluated for presence of BCG scar. Characteristics of study participants are described in Table 1. Additional file 1 presents the characteristics of infants with and without health card.

A total of 7612 children under the age of 36 months whose national health card was evaluated were BCG vaccinated in the district of Manhiça, yielding a BCG coverage of 97.4%. Table 2 and Fig. 2 show the vaccination coverage for all EPI vaccines administered in the district of Manhiça in the first year of life during the years 2011 to 2014. Coverage for each of the four doses of Oral Polio Vaccines were: 96.3%, 95.6%, 93.8% and 92.1%. For the pentavalent DPT/HepB/Hib vaccine, coverage was 96%, 94.5% and 93%. Measles vaccine was received around month 9 of life by 85.6% of infants. Around 90.2% of all study children had received all four doses of Oral Polio Vaccine and 91.8% of the doses of the pentavalent vaccine DPT/HepB/Hib. We found no differences in coverage for any of the vaccines by year of vaccination.

The multivariable logistic regression model revealed that children born in the municipality of Maluana had 89% higher odds of not receiving the vaccine compared to those born in central Manhiça (OR = 1.89, 95% CI: 1.18-3.00). Mothers' marital status (divorced or not living with a male companion vs married or living with a male companion) showed a weak association with lack of vaccination: OR = 1.66 95% CI: 0.81-3.37) (Table 3).



Variable ^a	n	%	Variable	n	%
Sex			Mother's antenatal visit	S	
Воу	3979	50.4	1 to 2	170	9.8
Girl	3921	49.6	3 or more	1573	90.3
Number of siblings			Place of delivery		
None	9	0.5	Health centre	1665	95.6
1 to 2	851	48.8	Home/Way to hospital	77	4.4
3 or above	883	50.7	Type of birth		
Season of birth			Natural	1655	95.0
Rainy	4329	54.8	C-Section	88	5.0
Dry	3574	45.2	Distance to health cent	re	
Wealth Index			Less than 5 km	988	19.8
1st Quintile	1312	18.4	More than 5 km	3994	80.2
2nd Quintile	1478	20.8	Mother's marital status		
3rd Quintile	1450	20.4	Single	513	10.1
4th Quintile	1451	20.4	Married/Union	3909	77.2
5th Quintile	1418	20.0) Divorced/Separated 64		12.7
Area			Mother's education		
Manhiça Sede	1706	21.6	No education	2110	43.0
3 de Fevereiro	1593	20.2	Primary	2308	47.0
Ilha Josina Machel	144	1.8	Secondary or 4 Higher		10.0
Xinavane	2215	28.0	Mother's religion		
Maluana	1689	21.4	Christian	2126	44.5
Calanga	556	7.0	Muslim	42	0.9
			Traditional African	2176	45.5
			Others	435	9.1

^a Many variables presented missing data due to lack of completeness of the questionnaire, or because some of them were implemented in different years

No other factors were associated with lack of BCG vaccination.

Scar assessment

From the 9512 adults who responded to the interview, irrespective of whether they presented the national health card or not, 8298 children could be directly observed for the presence of BCG-compatible scar. Coverage was 99.0% and 97.9% among children with and without a health card respectively. Therefore, when children are vaccinated with BCG (according to the health card), failure to develop the typical scar would occur in less than 1% in this population. We did not find any statistically significant association with lack of BCG scar. There were 174 children who were not BCG vaccinated according to the card, but 144 of them presented a BCG-compatible scar (82.8%).

Timeliness of BCG

Figure 3 represents the distribution of BCG vaccines administered to children starting from the day of birth onwards. The results indicate that 93.4% of vaccinated children received BCG within the first 28 days of life. The factors associated with the administration of BCG in the first 28 days of life are described in Table 4. The only factor associated with a timely BCG administration is not being born by a cesarean section (for which OR = 0.40, *p*-value 0.021). In other words, children born through a cesarean section are 60% less likely to have an adequate administration of BCG vaccine.

Discussion

Main findings

This study provides population estimates of BCG administration by two different methods in a large cohort of children. It shows that vaccine coverage in Manhiça district was very high for all vaccines administered in the first year of life, surpassing the international targets for EPI vaccine coverage. This finding is in line with results presented from similar studies about EPI vaccine coverage in Mozambique [29].

This is the first vaccination coverage study in the country using data collected by a HDSS. This preliminary information could be very relevant for future vaccine trials and a proxy for other health interventions. It is also important to highlight the importance of data registries in LMIC to monitor health systems' performance, resource allocation planning and progress in immunization strategies. These findings call for an improved system to collect information to be used for assessing vaccine coverage, and which could hopefully be used to compare across different countries.

In the period from 2011 to 2014, BCG coverage was 97.4%, higher than the estimation of 86.3% in Maringue District, Sofala Province (centre Mozambique) [12] and the nationwide 94% estimation by WHO [28]. The results of high coverage could be explained because of the likely better health infrastructure in the district than national standards, which include two referral hospitals plus the existence of a research centre (the CISM, which conducts operational and translational research). The latter, conducts at least one visit per year to each household for the purpose of HDSS work rounds of data collection in the district, which could potentially affect vaccination-seeking behaviour in the community. However, selection bias might have occurred since there is a proportion of subjects who fail to provide a health card. Although the main stated reason was that the caregivers could not find the card, if those who did not find the card had lower vaccine coverage, our estimates might represent a slight overestimation of the true coverage. An extra source of potential selection bias is that those

Table 2 Vaccination coverage among children aged less than 36 months in the $lpha$	district of Manhiça (2011-2014)
---	---------------------------------

Name of the vaccine	Number of children vaccinated (by card)	Number of children not vaccinated (by card)	Total children evaluated for each vaccine ^b	%	95% CI
BCG	7613	204	7817	97.4%	(95.20, 99.59)
OPV0	7505	289	7794	96.3%	(94.17, 98.54)
DPT/HepB/Hib 1	7466	311	7777	96.0%	(93.83, 98.20)
OPV1	7434	338	7772	95.7%	(93.52, 97.88)
DPT/HepB/Hib 2	7336	425	7761	94.5%	(92.37, 96.71)
OPV2	7274	477	7751	93.8%	(91.70, 96.03)
DPT/HepB/Hib 3	7195	546	7741	92.9%	(90.84, 95.16)
OPV3	7126	608	7734	92.1%	(90.03, 94.32)
All OPV ^a	7031	778	7809	90.0%	(88.07, 92.30)
All DPT/HepB/Hib ^a	7145	640	7785	91.8%	(89.72, 93.99)
Measles	6509	1093	7602	85.6%	(83.55, 87.73)

BCG Bacille-Calmette Guerin, OPV Oral Polio Vaccine, DPT/HepB/Hib Diphteria Pertussis Tetanus/Hepatitis B/Haemophinlus influenzae type b

^a All OPV or All DPT/HepB/Hib, refers to all doses of the vaccine having been correctly registered. It is lower than the last dose due to absence/incorrect documentation of some of the previous doses

^b Only eligible children (those who should have received a vaccine according to their age at the time of the visit and whose health card was assessed, readable and without missing dates) were included in this column

born in that period who died before the HDSS census rounds might have had lower BCG coverage. However, the effect of this bias, albeit unknown, could be limited, since those with and without vaccination card had similar coverages measured by the presence of scar.

We found no statistically significant associations with lack of BCG vaccination, except living in the municipality of Maluana. These findings might be explained by the small number of non-vaccinated individuals (random error) or other social factors that will require qualitative approaches in order to be identified. Very few BCG vaccinated children (according to their health cards) in the district of Manhiça fail to develop the scar. These results are comparable with findings of scar failure in other countries, ranging from 1 to 20% [13, 38, 39]. Potential observer bias could have taken place, since field workers were not blind to the child heath card information. Nonetheless, the proportion of scar formation in children with and without health card was similar to that of BCG vaccinated infants. If these findings were a true overestimation, the reason behind could be a systematic poor evaluation of the presence of BCG scar. Conversely, the fact that many children with



of children lacking with BCG informatio according to card number of children with BCG informatio according in the card OR (95%CI) p-value Sex	Variable	Number	Total	Bivariate analysis		Multivariable analys	is
Sex Male 101 (2.6) 3932 1.0 Female 102 (2.6) 3882 1.02 (0.77-1.35) 0.926 Number of siblings None 0 (0) 9 - 1 to 2 11 (1.3) 844 0.67 (0.31-1.44) 3 or above 17 (1.9) 880 1.00 0.305 Season of birth V V 4288 1.00 0.578 Weathr Index V 132 (2.2) 1.312 1.00 0.578 Vealth Index V V 1.00 1.00 1.00 Ist Quintile 42 (3.2) 1.312 1.00 1.00 1.00 And Quintile 14 (2.8) 1450 0.82 (0.52-1.28) 1.00 1.00 Ist Quintile 41 (2.8) 1450 0.90 (0.58-1.40) 1.00 1.00 Ist Quintile 14 (2.8) 1450 0.90 (0.58-1.40) 1.00 1.00 Ist Quintile 14 (2.8) 1450 0.61 (0.37-0.99) 1.00 1.00 1.00 1	of children lacking BCG according to card	number of children with BCG informatio in the card	OR (95%CI)	<i>p</i> -value	OR (95%CI)	<i>p</i> -value	
Male101 (2.6)39321.0Female102 (2.6)3821.02 (0.77-1.35)0.926Nome102 (2.6)3.821.02 (0.77-1.35)0.926Nome0.0091 to 20.0191 to 211.01840.67 (0.31-1.44)-3 or above17.19.801.003.05Surveror birthRainy0.81 (2.5)3.291.09 (0.82-1.44)0.578I to 49.62.3.291.09 (0.82-1.44)0.578I st Quintile42 (3.2)1.3121.00-I st Quintile42 (3.2)1.4780.82 (0.52-1.28)-I to Quintile41 (2.8)1.4500.90 (0.58-1.40)-I th Quintile28 (1.9)1.4510.61 (0.37-0.99)-	Sex						
Female102 (2.6)38821.02 (0.77-1.35)0.926Nome0.009-Nome0.009-1 to 21.01.0084.000.67 (0.31-1.44)3 or above17.19.0080.001.00Jor above17.19.0080.001.00Jor above108 (2.501.00Jor J0.62.001.00Jor J0.62.001.00Jor J0.62.001.00Jor J1.02.001.00Jor J1.02.001.00 <td>Male</td> <td>101 (2.6)</td> <td>3932</td> <td>1.0</td> <td></td> <td></td> <td></td>	Male	101 (2.6)	3932	1.0			
None0(0)9-1 to 211 (1.3)840.67 (0.31-1.44)3 or above17 (1.9)801.000.305server or birthkainy108 (2.5)4281.00by96 (2.7)3521.09 (0.82-1.44)0.578by12 (2.3)1.290.578by12 (2.3)1.210.21set or birth1.211.001.21by12 (2.3)1.210.21 (2.3)set or birth1.230.21 (2.3)1.21set or birth1.410.21 (2.3)1.21	Female	102 (2.6)	3882	1.02 (0.77-1.35)	0.926		
None0(0)9-1 to 211 (1.3)8440.67 (0.31-1.44)3 or above17 (1.9)8801.000.305substrainedkainy108 (2.5)1.00loy96 (2.7)35291.09 (0.82-1.44)0.578bit HutesI squintile42 (3.2)1321.00a fuquintile42 (3.2)1321.00and Quintile38 (2.6)14780.82 (0.52-1.28)and Quintile41 (2.8)14500.90 (0.58-1.40)and Quintile28 (1.9)14510.61 (0.37-0.99)	Number of siblings						
1 to 211 (1.3)8440.67 (0.31-1.44)3 or above17 (1.9)8801.000.305Second birthkainy108 (2.5)42881.00Dry96 (2.7)35291.09 (0.82-1.44)0.578kuintileI st Quintile42 (3.2)13121.002nd Quintile42 (3.2)14780.82 (0.52-1.28)3rd Quintile41 (2.8)14500.90 (0.58-1.40)4t Quintile28 (1.9)14510.61 (0.37-0.99)	None	0 (0)	9	-			
3 or above17 (1.9)8801.000.305Season of birthRainy108 (2.5)42881.00Dy96 (2.7)35291.09 (0.82-1.44)0.578Usuith IndexI st Quintile42 (3.2)13121.002nd Quintile38 (2.6)14780.82 (0.52-1.28)3rd Quintile41 (2.8)14500.90 (0.58-1.40)4th Quintile28 (1.9)14510.61 (0.37-0.99)	1 to 2	11 (1.3)	844	0.67 (0.31-1.44)			
Bainy 108 (2.5) 4288 1.00 Dry 96 (2.7) 3529 1.09 (0.82-1.44) 0.578 V=Varth 96 (2.7) 1312 1.00 1 st Quintile 42 (3.2) 1312 1.00 2nd Quintile 38 (2.6) 1478 0.82 (0.52-1.28) 3rd Quintile 41 (2.8) 1450 0.90 (0.58-1.40) 4th Quintile 28 (1.9) 1451 0.61 (0.37-0.99)	3 or above	17 (1.9)	880	1.00	0.305		
Rainy 108 (2.5) 4288 1.00 Dry 96 (2.7) 3529 1.09 (0.82-1.44) 0.578 V=Vith Index V V V V 1st Quintile 42 (3.2) 1312 1.00 V 2nd Quintile 38 (2.6) 1478 0.82 (0.52-1.28) V 3rd Quintile 41 (2.8) 1450 0.90 (0.58-1.40) V 4th Quintile 28 (1.9) 1451 0.61 (0.37-0.99) V	Season of birth						
Dry 96 (2.7) 3529 1.09 (0.82-1.44) 0.578 W=alth Index 1 st Quintile 42 (3.2) 1312 1.00 2nd Quintile 38 (2.6) 1478 0.82 (0.52-1.28) 3rd Quintile 41 (2.8) 1450 0.90 (0.58-1.40) 4th Quintile 28 (1.9) 1451 0.61 (0.37-0.99)	Rainy	108 (2.5)	4288	1.00			
Wealth Index 1st Quintile 42 (3.2) 1312 1.00 2nd Quintile 38 (2.6) 1478 0.82 (0.52-1.28) 3rd Quintile 41 (2.8) 1450 0.90 (0.58-1.40) 4th Quintile 28 (1.9) 1451 0.61 (0.37-0.99)	Dry	96 (2.7)	3529	1.09 (0.82-1.44)	0.578		
1st Quintile42 (3.2)13121.002nd Quintile38 (2.6)14780.82 (0.52-1.28)3rd Quintile41 (2.8)14500.90 (0.58-1.40)4th Quintile28 (1.9)14510.61 (0.37-0.99)	Wealth Index						
2nd Quintile38 (2.6)14780.82 (0.52-1.28)3rd Quintile41 (2.8)14500.90 (0.58-1.40)4th Quintile28 (1.9)14510.61 (0.37-0.99)	1st Quintile	42 (3.2)	1312	1.00			
3rd Quintile41 (2.8)14500.90 (0.58-1.40)4th Quintile28 (1.9)14510.61 (0.37-0.99)	2nd Quintile	38 (2.6)	1478	0.82 (0.52-1.28)			
4th Quintile 28 (1.9) 1451 0.61 (0.37-0.99)	3rd Quintile	41 (2.8)	1450	0.90 (0.58-1.40)			
	4th Quintile	28 (1.9)	1451	0.61 (0.37-0.99)			
5th Quintile 38 (2.7) 1418 0.85 (0.54-1.33) 0.325	5th Quintile	38 (2.7)	1418	0.85 (0.54-1.33)	0.325		
Administrative Post	Administrative Post						
Manhiça Sede 37 (2.2) 1690 1.00 1.00	Manhiça Sede	37 (2.2)	1690	1.00		1.00	
3 de Fevereiro 34 (2.2) 1582 0.98 (0.61-1.57) 0.79 (0.45-1.39)	3 de Fevereiro	34 (2.2)	1582	0.98 (0.61-1.57)		0.79 (0.45-1.39)	
Ilha Josina Machel 1 (0.7) 144 0.31 (0.04-2.29) 0.32 (0.04-2.39)	Ilha Josina Machel	1 (0.7)	144	0.31 (0.04-2.29)		0.32 (0.04-2.39)	
Xinavane 57 (2.6) 2183 1.20 (0.79-1.82) 1.05 (0.59-1.89)	Xinavane	57 (2.6)	2183	1.20 (0.79-1.82)		1.05 (0.59-1.89)	
Maluana 65 (3.9) 1671 1.78 (1.18-2.68) 1.89 (1.18-3.00)	Maluana	65 (3.9)	1671	1.78 (1.18-2.68)		1.89 (1.18-3.00)	
Calanga 10 (1.8) 547 0.83 (0.41-1.68) 0.007 0.47 (0.14-1.54) 0.003	Calanga	10 (1.8)	547	0.83 (0.41-1.68)	0.007	0.47 (0.14-1.54)	0.003
Antenatal Visits	Antenatal Visits						
1 to 2 3 (1.7) 168 1.00	1 to 2	3 (1.7)	168	1.00			
3 or above 25 (1.6) 1565 0.89 (0.37-2.98) 0.854	3 or above	25 (1.6)	1565	0.89 (0.37-2.98)	0.854		
Place of delivery	Place of delivery						
Health centre 28 (1.7) 1655 1.00	Health centre	28 (1.7)	1655	1.00			
Home/way to hospital 0 (0) 77 – –	Home/way to hospital	0 (0)	77	-	-		
Type of delivery	Type of delivery						
Natural 26 (1.6) 1645 1.00	Natural	26 (1.6)	1645	1.00			
C-Section 2 (2.3) 88 1.44 (0.34-6.2) 0.618	C-Section	2 (2.3)	88	1.44 (0.34-6.2)	0.618		
Mother's marital status	Mother's marital status						
Single 12 (2.4) 510 1.00 1.00	Single	12 (2.4)	510	1.00		1.00	
Married/Union 84 (2.2) 3868 0.92 (0.49-1.70) 0.99 (0.53-1.82)	Married/Union	84 (2.2)	3868	0.92 (0.49-1.70)		0.99 (0.53-1.82)	
Divorced/Separated 23 (3.6) 631 1.57 (0.77-3.19) 0.083 1.66 (0.81-3.37) 0.092	Divorced/Separated	23 (3.6)	631	1.57 (0.77-3.19)	0.083	1.66 (0.81-3.37)	0.092
Mother's education	Mother's education						
No education 52 (2.5) 2089 1.00	No education	52 (2.5)	2089	1.00			
Primary 54 (2.4) 2284 0.95 (0.64-1.39)	Primary	54 (2.4)	2284	0.95 (0.64-1.39)			

Table 3 Analysis of factors associated to lack of BCG vaccination

Variable	Number	Total	Bivariate analysis		Multivariable analy	ysis
	of numbe children children lacking with BC BCG informa according in the o to card	number of children with BCG informatio in the card	OR (95%CI)	<i>p-</i> value	OR (95%CI)	<i>p</i> -value
Secondary or higher	11 (2.3)	485	0.91 (0.47-1.75)	0.943		
Mother's religion						
Christian	48 (2.3)	2104	1.00			
Muslim	1 (2.5)	40	1.09 (0.15-8.16)			
Traditional African	53 (2.5)	2158	1.07 (0.73-1.60)	0.902		
Others	8 (1.8)	428	0.82 (0.38-1.74)			
Distance to health centre						
Less than 5 km	17 (1.7)	983	1.00			
More than 5 km	88 (2.2)	3961	1.27 (0.75-2.15)	0.339		

Table 3 Analysis of factors associated to lack of BCG vaccination (Continued)

no record of BCG in their card presented BCG scar could lead to a potential underestimation of coverage estimates based solely on immunization card. This could be due to bad documentation of BCG vaccination in the immunization card (or cases where the card was lost and replaced, and information could not be updated). Unfortunately these potential explanations cannot be verified.

Recent studies showing scar beneficial effects, such as lower mortality in infants with scar [5, 11], have opened the debate about re-vaccination [5, 40] among those failing to develop a scar. Some have suggested that scarring could be a method to monitor vaccination performance in resource-poor settings. On the other hand, BCG is not recommended in HIV suspected cases and HIVrelated immunosuppression may play a role in scar response. In a high HIV burden country such as Mozambique, where most children are BCG vaccinated regardless of their HIV status, we expected a lower scar formation rate.

The timing of vaccination is very important in order to reach the maximum protection, but also for being a proxy of non-adherence and reduce of vaccination. [16, 17, 20, 22]. In order to measure if BCG was appropriately administered, we consider a timely vaccination if it occurred within the 28 days of life, as recommended by WHO [19]. The results show a low proportion of delayed BCG vaccination (6.6%), compared to 33% found in Tanzanian the year 2004 [15]. However, the definition of delayed BCG vaccination differs from author to author, [19] some consider it happens only after 8 weeks or even after 56 days [17] after birth, thus comparability with other studies needs to be cautious. The only factor associated with timely BCG vaccination was being delivered through a caesarean section. It is closely related with being born in a health facility, with a skilled birth attendant, where they will have the BCG vaccine ready to be administered after birth.

This study had several limitations. First, selection bias could have occured since we could only visit children



weak children OR (95%C) p-value OR (95%C) p-value Sex	Variable	Timely BCG T	Total	Bivariate analysis		Multivariable analysis	
Soc Nale 3449 (93.4) 3691 1.00 Penale 3399 (93.3) 3642 0.99 (0.82-1.16) 0.942 Number of siblings None 9 (100) 9 1.00 1 1 to 2 70 (95.4) 766 1.25 (10.80-1.95) 3 3 Soason of birth Barbove 769 (94.4) 815 1.00 0.335 Soason of birth Barbove 319 (92.5) 3.324 1.03 (0.96-1.24) 0.721 Wealth Index 113 (0.93.5) 1.218 1.00 2.344 1.03 (0.96-1.24) 0.721 Wealth Index 1136 (93.3) 1.218 1.00 2.344 1.03 (0.96-1.24) 0.721 Washing Social Associal Ass		vaccinated (%)	children with BCG	OR (95%CI)	<i>p</i> -value	OR (95%CI)	<i>p</i> -value
MaleS499 (93.0)S691100Formale3399 (93.0)64200.492-11900.492Number of sblings9100.091.001.01In a 0900.017801.25 (0.05-1.95)3 or above30 ar above	Sex						
Fende 3399 (93.3) 3642 0.88 (0.82-1.18) 0.842 Number of sblings 1.00 1.00 1.00 None 9 (0.00) 9 1.00 0.335 3 or above 760 (94.4) 130 0.335 5.000 Season of Brith 1 1.00 0.335 5.000 Bany 3/43 (93.3) 4012 1.00 0.723 5.000 Season of Brith 1 1.03 (9.03.5) 3.324 1.03 (9.04.7) 0.723 5.000 Season of Brith 1 15.000 0.723 5.000 1.000 5.0000	Male	3449 (93.4)	3691	1.00			
Number of siblingsNone010091001 to 200 (04)91003 or above09 (04)100.33Sestor of bith100.33100Image: Similar of bith1000.33100Dy318 (03)402103 (08-1.24)0.23Vestor of bith1000.33100100Umage: Similar of bith1000.23100Similar of bith110 (03)103 (02)100200 (03)136 (03)105 (027-142)1003 of Quintle106 (03)103 (03)100 (04)3 of Quintle100 (03)100 (04)1003 of Quintle100 (03)100 (04)1003 of Revenio106 (04)101 (04)1003 of Revenio104 (04)101 (04)1003 of Revenio104 (03)1001003 of Robove141 (03)1001003 of above194 (03)1501003 of above194 (03)1501003 of above194 (03)1521004 markin192 (14)1001001 to 2194 (03)1521001 to 2194 (04)1521001 to 2194 (04)1521001 to 2194 (04)1521001 to 2194 (04)1521001 to 2194 (04)1001001 to 2194 (04)1001001 to 2 </td <td>Female</td> <td>3399 (93.3)</td> <td>3642</td> <td>0.98 (0.82-1.18)</td> <td>0.842</td> <td></td> <td></td>	Female	3399 (93.3)	3642	0.98 (0.82-1.18)	0.842		
None9 (100)91.001 to 2.750 (95.4)766125 (028-1.59)3 or above750 (95.4)768125 (028-1.59)3 or above743 (93.3)4012100Dy3108 (93.3)4012100Dy3108 (93.3)1218100Dy3108 (93.3)12181.002 columble1289 (95.5)1378105 (07.71.42)3 rd Quintile1269 (93.5)1378105 (07.71.42)4 th Quintile1269 (93.5)13611.11 (028-1.55)5 th Quintile1260 (94.3)13611.11 (028-1.55)4 th Quintile1260 (94.3)13611.11 (028-1.55)5 th Quintile1364 (93.0)14660.71 (57.1.8)4 th Manking Socie1364 (93.0)14610.71 (57.1.8)6 serverion1364 (93.0)14660.71 (57.1.8)7 Mankane1941 (93.5)137101 (046-223)7 Mankane1949 (93.6)137101 (046-23)7 Makuana1364 (93.0)141 (97.21.80)0.0187 In 21364 (93.0)137101 (94.6-23)7 In 21369 (93.0)137101 (94.6-23)7 In 21369 (93.0)1361114 (97.21.80)7 Makuana1364 (93.0)1361134 (97.21.80)7 In 213691361134 (97.21.80)8 In 21361130 (136.91.91)13619 In 21361134 (97.21.80)13619 In 21361130 (137.91.91)130 (137	Number of siblings						
İ to 2750 (95.4)766125 (030-159)3 or above769 (94.0)10.00.335Sesson of bith1.000.335Bainy3/24 (0.3.3)4.0121.00Dy3108 (0.3.5)3.241.03 (0.8-1.24)0.23Waalt1.150 (0.911)1.03 (0.8-1.24)0.23Bainy1.05 (0.77-1.42)1.14 (0.91-1.52)1.14 (0.91-1.52)Jard Quintile1.28 (0.93.0)1.361.10 (0.8-1.65)0.704Sh Quintile1.260 (0.43)1.361.10 (0.8-1.65)0.704Sh Quintile1.260 (0.43)1.361.10 (0.8-1.62)1.14 (0.8-1.62)Sh Quintile1.260 (0.43)1.361.001.14 (0.8-1.25)Administrative Post1.10 (0.46-2.34)1.10 (0.46-2.34)1.10 (0.46-2.34)Manan1.260 (0.93)0.270.2741.14 (0.72-1.80)Malana1.961 (0.92)1.14 (0.72-1.80)0.0181.14 (0.72-1.80)Adman1.961 (0.92)1.14 (0.72-1.80)0.0181.14 (0.72-1.80)Adman1.961 (0.92)1.14 (0.72-1.80)0.0181.14 (0.72-1.80)Ja or above1.961 (0.92)1.14 (0.72-1.80)0.0181.14 (0.14 (0.14)Place of delivey1.14 (0.72-1.80)0.0181.14 (0.14 (0.14)Place of delivey1.14 (0.72-1.80)0.0580.01Place of delivey1.14 (0.72-1.90)0.5971.14 (0.72-1.90)Place of delivey1.14 (0.72-1.90)0.5971.14 (0.72-1.90)Place of delivey1.14 (0.	None	9 (100)	9	1.00			
Sarabove Same Same p769 (94.4)8151.000.335Same Same same p374 (93.3)40121.00Dry3240 (33.0)33.401.03 (0.61.24)0.23Weath 	1 to 2	750 (95.4)	786	1.25 (0.80-1.95)			
Season of birthRany374 (0.3)4101.00Dy310 (085)31201.00Ball136 (08.3)1.2181.02Sal Quintile1266 (03.1)1.3780.97 (0.71-42)3rd Quintile1268 (03.2)1.3780.97 (0.71-42)3rd Quintile1269 (03.2)1.3611.11 (0.81-1.52)3rd Quintile1269 (03.2)1.3611.11 (0.81-1.52)3rd Quintile1269 (03.1)1.3621.11 (0.81-1.52)3rd Quintile1269 (03.1)1.3621.004dministative Post1.3621.001.37Manhicz Sede194 (03.0)1.4621.003 de Forerion134 (01.7)1.001.01 (0.46-2.23)Manane194 (03.0)1.3620.24 (0.440.65)All Ini J. 301.3611.01 (0.46-2.23)1.52Ananae194 (05.0)1.520.73 (0.57-1.03)All Ini J. 301.5600.64 (0.460.65)1.52All Ini J. 301.5600.64 (0.460.65)1.52All Ini J. 301.5600.73 (0.39-1.200.731All Ini J. 301.5600.73 (0.39-1.200.731Pice of delivey1.521.520.731Pice of delivey1.521.521.52Pice of delivey1.521.521.52Single1.53 (0.52.0)0.530.40 (0.46.16.17)All Interme1.53 (0.52.0)0.541.50 (0.76.294)Binder1.52 (0.52.0)0.541.50 (0.76.294) <t< td=""><td>3 or above</td><td>769 (94.4)</td><td>815</td><td>1.00</td><td>0.335</td><td></td><td></td></t<>	3 or above	769 (94.4)	815	1.00	0.335		
RainyS134 (9.3)4012100Dy318 (93.5)3241.03 (0.86-1.24)0.723Beather136 (93.5)1371.03 (0.86-1.24)7.73Bard Quintile136 (93.5)1371.001.41 (0.81-1.52)3rd Quintile1280 (93.1)139.600.70(21-1.32)1.11 (0.81-1.52)3rd Quintile1280 (93.1)136.001.11 (0.81-1.52)1.41 (0.81-1.52)3rd Quintile1280 (93.1)136.001.11 (0.81-1.52)1.41 (0.81-1.52)Administrative Post13461.620.70(25-1.03)1.41 (0.81-1.52)Administrative Post129 (94.6)158.21.001.41 (0.42-2.3)Anankel129 (94.6)158.21.01 (0.46-2.3)1.41 (0.71-1.03)Ananac1491 (93.1)169.00.10 (0.46-2.3)1.41 (0.71-1.03)Ananac1491 (93.1)150.00.42 (0.02-1.08)1.41 (0.71-1.03)Ananac1491 (93.1)150.00.101.41 (0.71-1.83)0.11Ananac1491 (93.1)1.500.711.51 (0.11)1.51 (0.11)Ananac148 (95.1)1.520.011.51 (0.11)1.51 (0.11)Place148 (95.1)1.521.001.51 (0.11)1.51 (0.11)Place149.11.521.52 (0.11)1.50 (0.72, 94)1.51 (0.11)Place149.11.521.52 (0.11)1.50 (0.72, 94)1.50 (0.72, 94)Place149.11.51 (0.11)1.50 (0.72, 94)1.50 (0.72, 94)1.50 (0.72, 94)P	Season of birth						
Dy308 (93)334103 (080-12)0.23Wath Index11601001136 (93)12181002nd Quinlie1289 (93)137050 (071-12)3rd Quinlie1260 (93)1361111 (081-152)4th Quintle1260 (93)1361119 (086-165)0.7044dministative Not136410014004dministative Rose126 (93.0)14660.70 (057-103)4dministative Rose129 (94.0)130101 (046-22.3)4dmana193 (93.0)14660.70 (057-103)4duana194 (93.0)1010.402-23)4duana194 (95.0)1500.018Aduana194 (95.0)1511.00Aduana194 (95.0)1520.011 to 2148 (95.0)1551.003 or above194 (95.0)1531.00Place of delivery11.000.57Hauthertine145 (95.0)1531.00Attural145 (95.0)1.531.00CSection76 (90.4)8.300.40 (0.180.87)Natural145 (95.0)1.541.00CSection76 (90.4)1.00Natural1531.00Attural1.50 (0.62.94)Natural1.50 (0.62.94)Natural1.50 (0.62.94)Natural1.50 (0.62.94)Natural1.50 (0.62.94)Natural1.50 (0.62.94)Natural1.50 (0.62.94)Natural	Rainy	3743 (93.3)	4012	1.00			
Watch IndexI Quintle136 (03,)178100126 (04,011)128 (03,)137105 (077.12,)3rd Quintle126 (03,)136107 (071.12,)4th Quintle128 (03,)136110 (03e1.65)0.7045th Quintle120 (04,3)136110 (03e1.65)0.704Attrinistative Post110011Admina Sede136 (03,0)1660.70413 de Forenion1364 (03,0)162113 da Forenion1364 (03,0)1630.701Anavane194 (03,5)2070.82 (02e3.108)11Anavane194 (03,5)1500.7011Anavane194 (03,5)1500.7011Anavane194 (03,5)1500.7111Anavane194 (03,5)15310011Anavane193 (03,6)13310011Anavane193 (03,6)131100100100Anavane193 (03,6)164 (03,20,3)0.6111Anavane193 (03,6)164 (03,20,3)0.6111Anavane193 (03,6)164 (03,20,3)0.6111Anavane193 (03,6)164 (03,20,3)0.6111Anavane193 (03,6)164 (03,20,3)0.6111Anavane193 (03,6)164 (03,20,3)0.6111Anavane1	Dry	3108 (93.5)	3324	1.03 (0.86-1.24)	0.723		
1 st Quintile136 (93.3)12181.002 rd Quintile1289 (93.5)1378105 (0.77.1.42)3 rd Quintile1269 (93.6)13610.97 (0.71.3.2)4 rh Quintile1260 (94.3)13611.11 (0.81-1.5.2)5 rh Quintile1260 (94.3)13611.00Administrative PostManhiga Sede1496 (94.6)158.21.00Administrative Post1 flab Josina Machel139 (94.6)1301.01 (0.46-2.23)3 rd Bevereiro134 (93.0)14660.77 (0.57-1.03)3 rd Bevereiro1941 (93.5)2070.82 (0.62-1.08)Maluan131 (91.7)15600.64 (0.48-0.85)4 rule143 (91.7)15600.64 (0.48-0.85)4 rule1380 (94.8)1551.003 or above1380 (94.8)1551.003 or above1380 (94.8)1551.003 or above1380 (93.0)1531.00Health centre1458 (95.0)1531.00rupe-dellwey1453 (95.2)1521.00rupe-dellwey153 (95.2)1.500.058rupe-dellwey153 (95.2)1.501.00rupe-dellwey1.50 (0.76.2.94)0.058rupe-dellwey1.50 (0.76.2.94)0.058rupe-dellwey1.50 (0.76.2.94)0.058rupe-dellwey1.50 (0.76.2.94)0.050rupe-dellwey1.60 (1.19.2.31)1.50 (0.76.2.94)rupe-dellwey1.60 (1.92.31)	Wealth Index						
2nd Quintile 1289 (93,5) 1378 105 (0,77.1.42) 3rd Quintile 1265 (93,1) 1359 0.97 (0,71.1.32) 4th Quintile 1278 (93,9) 1361 1.11 (0,81-1.52) 5th Quintile 1278 (93,9) 1361 1.11 (0,81-1.52) 4th Cuintile 1278 (93,9) 1361 1.11 (0,81-1.52) Atministrative Post Winning Sede 1496 (94,6) 1582 100 4ministrative Post 123 (94,6) 130 101 (0.46-2.23) Vintile Vintile Manking Sede 1491 (93,5) 207 0.82 (0.62-1.08) Vintile Vintile Vintile Mankara 1431 (9.7) 1560 0.64 (0.484 .085) Vintile Vintile<	1st Quintile	1136 (93.3)	1218	1.00			
and Quintile1265 (93.1)13590.97 (0.71-1.2)4th Quintile1278 (93.9)13611.11 (0.81-1.52)5th Quintile1260 (94.3)136.01.19 (0.86-1.55)0.704Administrative Post1466 (94.6)158.20.003 de Feveriero1364 (93.0)14660.77 (0.57-1.03)-4 Jasina Machel123 (94.6)130.00.10 (0.46-2.23)Manhag Machel1341 (91.7)15600.64 (0.48.05)Alenaral1341 (91.7)15600.64 (0.48.05)Galanga496 (95.2)1551.00Attenatal Visis1 to 2148 (95.5)1551.009 onbove1380 (94.8)14550.37 (0.29-1.80)0.5079 nabove1380 (94.8)153.51.009 nabove168 (95.0)153.51.009 nabove198 (94.8)153.51.009 nabove198 (95.2)153.51.00	2nd Quintile	1289 (93.5)	1378	1.05 (0.77-1.42)			
4th Quintile128 (93.9)1361.11 (0.81-1.52)5th Quintile126 (94.3)136.01.19 (0.86-1.65)0.704Administrative Post158.21.00	3rd Quintile	1265 (93.1)	1359	0.97 (0.71-1.32)			
Sh Quintile1260 (9.3)1361.19 (0.86-1.65)0.704Administrative PostManhiga Sede1496 (9.6)15821.00J da (9.3)14660.70 (0.57-1.03)J ha Josina Machel123 (9.6)1000.10 (0.46 - 2.33)J ha Josina Machel123 (9.6)1000.82 (0.62-1.08)J kinavane1941 (9.5)0.82 (0.62-1.08)J kinavane1941 (9.5)0.64 (0.49 e.05)J calanga496 (9.52)5.11.14 (0.72-1.80)0.018Attenatal Visits151.00J to 21380 (9.8)1551.00J ora obove0.93 (9.2)740.73 (0.29-1.86)0.507Pice of delivery1551.00Healt charter1458 (9.50)1521.000.507Natural1453 (9.52)740.73 (0.29-1.86)0.507Natural1458 (9.50)1521.000.018Type of delivery1.001.001.00Matural status1520.40 (9.02.10.3)0.5070.201Single24 (9.004711.001.001.00Matural status521.61 (9.2.13)1.50 (0.6.2.40)0.901Juried/Union241 (9.38)6491.61 (1.9.2.31)1.50 (0.6.2.40)0.901Juried/Union153 (9.6.11)1.021.50 (0.6.2.40)0.901Juried/Union154 (9.41)1.021.50 (0.6.2.40)0.901	4th Quintile	1278 (93.9)	1361	1.11 (0.81-1.52)			
Administrative PostManhiça Sede1969 (94)15821.00İ de Fevereiro1364 (93.001640.27 (0.57-1.0.3)İ ha Josina Machel123 (94.6)130101 (0.45-2.2.3)Manaa191 (93.5)0.27 (0.52-1.0.8)1.41 (0.72-1.80)Maluana131 (91.7)1620.64 (0.48-0.85)Calanga496 (95.2)0.211.14 (0.72-1.80)0.018Attenatal Visits114 (0.72-1.80)0.0181.41 (0.72-1.80)J to 2188 (95.2)1551.001.41 (0.72-1.80)J a rabove1830 (94.8)1550.011.41 (0.72-1.80)Pare-tot delivery1380 (94.8)1551.001.41 (0.72-1.80)Port-or delivery148 (95.0)1531.001.41 (0.72-1.80)Marual163 (95.0)1531.001.00Type-tot delivery1521.001.001.00Type-tot delivery1531.001.001.00Type-tot delivery1541.001.001.01Type-tot delivery1531.001.001.01Standard tot basista1.521.521.021.02Matural163 (95.2.0)1.521.021.021.02Matural tot basis1.541.001.001.011.02Matural tot basis1.541.641.641.541.54Matural tot basis1.541.641.641.541.54Matural tot basis1.541.641.64 </td <td>5th Quintile</td> <td>1260 (94.3)</td> <td>1336</td> <td>1.19 (0.86-1.65)</td> <td>0.704</td> <td></td> <td></td>	5th Quintile	1260 (94.3)	1336	1.19 (0.86-1.65)	0.704		
Manhiqa Sede1496 (946)15821003 de Fevereiro1364 (93.0)14660.77 (057-1.03)Iha Josina Machel123 (94.6)1300.10 (046-2.23)Mahana1941 (93.5)20770.82 (0.62-1.08)Galanga496 (95.2)52100.21 (0.21.80)Ja Janga496 (95.2)52101.14 (0.72-1.80)0.018Antenatu Wists115501.00I to 2148 (95.0)15500.87 (0.39-1.92)0.731Place of delivery115401.00Planeway to hospital69 (93.2)740.73 (0.29-1.86)0.507Type of delivery115271.001.00Type of delivery11543 (95.2)15271.001.00Scelon76 (9.02)740.48 (0.22-1.03)0.0580.40 (0.18-0.87)0.21Matural1453 (95.2)15271.001.001.001.00Cycedo Separated24 (90.0)4710.001.001.00Matried/Union342 (93.0)6491.66 (1.19-2.31)1.50 (0.56-4.00)0.90Ibviter's education1536 (0.31)7641.88 (1.18-3.00)0.0061.50 (0.56-4.00)0.90Matried/Union186 (93.1)1.9731.601.50 (0.56-4.00)0.901.90Ibviter's education186 (93.1)1.9131.001.50 (0.56-4.00)0.90Matried/Union186 (93.1)1.9131.001.50 (0.56-4.00)0.90Ibviter's educ	Administrative Post						
§ de Feveriro1364 (33)14660.77 (057-103)Iha Josina Machel123 (94,0)1300.10 (046-223)Anavane1941 (93,5)0.82 (062-1.08)Jaluana1431 (91,7)15600.64 (048-0.85)Attenatal Visits511.14 (072-1.80)0.18Attenatal Visits1148 (95,0)1510.013 or above148 (95,0)1510.07 (0.73)Beith centre148 (95,0)1530.07 (0.73)Hendth centre149 (95,0)1530.01Hordway to hospital69 (93,2)740.73 (0.29-1.86)Mural145 (95,0)1530.01Lyber of delivery1400.73 (0.29-1.86)0.57Vertre delivery140143 (95,0)1520.05Joine of the centre1530.000.0511.00Lyber of delivery1521.000.0510.01Joine of the centre1530.010.010.01Joine of the centre1.020.0510.0210.021Matrial Status1521.001.000.021Joine of the centre1.011.001.011.01Joine of the centre1.021.001.011.01Joine of the centre1.021.011.011.01Joine of the centre1.021.011.011.01Joine of the centre1.021.011.011.01Joine of the centre1.021.011.011.01 <t< td=""><td>Manhiça Sede</td><td>1496 (94.6)</td><td>1582</td><td>1.00</td><td></td><td></td><td></td></t<>	Manhiça Sede	1496 (94.6)	1582	1.00			
Iha Josina Machel123 (94.6)130101 (0.46-2.23)Xinavane1941 (93.5)207082 (0.62-1.08)Maluana1431 (91.7)15600.64 (0.48-0.85)Calanga496 (95.2)5211.14 (0.72-1.80)0.018Attenatal Visits11.14 (0.72-1.80)0.018Attenatal Visits11.001.01Place of delivery1.850.87 (0.39-1.92)0.731Place of delivery1.950.73 (0.29-1.86)0.507Place of delivery1.931.001.00Type of delivery1.930.0181.00Verser of delivery1.930.0180.507Verser of delivery1.001.000.018Type of delivery1.011.000.018Verser of delivery1.920.0180.057Natural145 (95.2)152.71.001.00Natural145 (95.2)152.71.001.00Motion1.921.921.921.92Motion342 (90.0)1.921.901.90Motion342 (90.0)641.921.90Maried /Union1.921.931.911.90Motion1.921.931.921.90Motion1.941.931.911.90Motion1.941.911.901.91Motion1.941.911.911.91 <trr>Motion1.</trr>	3 de Fevereiro	1364 (93.0)	1466	0.77 (0.57-1.03)			
Xinavane1941 (93.5)2077082 (0.62-1.08)Maluana131 (91.7)15600.64 (0.48-0.85)Zinanga496 (95.2)511.14 (0.72-1.80)0.018Artenatal Visits3 or above188 (95.0)1550.00J to 2188 (95.0)1550.87 (0.39-1.92)0.731J to 2188 (95.0)15351.001.00Plact-of delivery51.005.075.07Plath centre1458 (95.0)7.331.005.07Maural69 (93.2)7.400.73 (0.29-1.86)0.5075.07Natural69 (93.2)7.571.001.001.00Type of delivery51.001.001.001.00Verseria1.92 (9.04)7.571.001.001.00Type of delivery51.011.001.001.00Matural424 (90.0)7.571.66 (1.19-2.31)0.0581.50 (0.76-2.94)0.01Mored/Separated324 (93.0)6.691.66 (1.19-2.31)1.50 (0.76-2.94)0.400.40Mored/Separated184 (93.1)9.731.601.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.94)1.50 (0.76-2.9	Ilha Josina Machel	123 (94.6)	130	1.01 (0.46-2.23)			
Maluana141 (91,7)15600.64 (0.48.0.85)Calanga496 (95.2)52 11.14 (0.72.1.80)0.18Atternatal Visits11.001.00J to 21380 (0.48)14550.87 (0.39.1.92)0.731Place of delivery1380 (94.80)15351.00Place of delivery1458 (95.0)74.000.7305.07Place of delivery1458 (95.0)74.000.7300.507Place of delivery1458 (95.0)74.000.5071.00Type of delivery1453 (95.2)74.000.5071.00Type of delivery1521.001.000.018Type of delivery1521.001.001.00Type of delivery1.011.001.000.006Moried Jubion142 (90.0)1641.001.50 (0.65.4.00)Moried Jubion183 (93.1)19731.001.50 (0.56.4.00)Moried Jubion183 (93.1)19731.001.50 (0.56.4.00)Moried Jubion183 (93.1)19731.001.50 (0.56.4.00)Moried Jubion183 (93.1)1.	Xinavane	1941 (93.5)	2077	0.82 (0.62-1.08)			
Calanga496 (95.)5211.14 (0.72-1.80)0.018Arrental Visits11003 or above148 (95.)1550.000.731Place of delivery1380 (94.80)14550.87 (0.39-1.92)0.731Place of delivery11530.001Place of delivery1458 (95.00)74.000.73 (0.29-1.86)0.507Type of delivery1453 (95.00)74.000.73 (0.29-1.86)0.507Type of delivery1453 (95.00)152.000.0580.40 (0.18-0.87)0.021Costoin153 (95.00)152.000.40 (0.22-1.03)0.0580.40 (0.18-0.87)0.021Matral1453 (95.00)152.000.40 (0.22-1.03)0.0580.40 (0.18-0.87)0.021Songle244 (90.00830.40 (0.22-1.03)0.0580.40 (0.18-0.87)0.021Matriel /Union321 (93.80)36491.66 (1.19-2.31)1.00 (0.62-9.40)0.401Morendo/Separated544 (94.00)561.88 (1.18-3.00)0.0661.50 (0.65-4.00)0.401Morendo/Separated183 (93.10)19731.001.50 (0.56-4.00)0.4010.401Primary194 (93.60)21311.09 (0.85-1.39)1.51 (1	Maluana	1431 (91.7)	1560	0.64 (0.48-0.85)			
Artenatal Visits1 to 2148 (95)1551.003 or above1380 (94.8)1450.87 (0.39.1.92)0.731Platorence1380 (94.8)1550.73 (0.29.1.86)0.507Plath centre168 (95.0)1530.005.07Health centre169 (93.0)7.30 (0.29.1.86)0.507Natural169 (93.0)1520.011.00C-Section7.90,04830.48 (0.22.1.03)0.0580.40 (0.18-0.87)0.021Natural159,0521.021.000.010.010.010.01Norreir Smartial status1.011.001.001.001.001.00Norreir Scattorion321 (93.8)36491.66 (1.19-2.31)0.0061.50 (0.56-4.00)0.401Norreir Scattorion1.021.601.88 (1.18-3.00)0.0061.50 (0.56-4.00)0.401Norreir Scattorion1.021.601.601.50 (0.56-4.00)0.401Norreir Scattorion1.021.001.50 (0.56-4.00)0.401Norreir Scattorion1.021.001.50 (0.56-4.00)0.401Norreir Scattorion1.021.021.50 (0.56-4.00)0.401Norreir Scattorion1.03 (0.86-2.09)0.4211.50 (0.56-4.00)0.401Norreir Scattorion1.03 (0.86-2.09)0.4211.50 (0.56-4.00)1.50 (0.56-4.00)Norreir Scattorion1.03 (0.86-2.09)0.4211.50 (0.56-4.00)1.50 (0.56-4.00)Norreir Scattorion1.03 (0.86	Calanga	496 (95.2)	521	1.14 (0.72-1.80)	0.018		
1 to 2148 (95.)1551003 or above1380 (94.8)145.000.87 (0.39.1.92)0.731PL	Antenatal Visits						
3 or above1380 (94.8)14550.87 (0.39-1.92)0.731Piertor et delivery1458 (95.0)15351.00Home/way to hospital60 (93.2)740.73 (0.29-1.86)0.507Type of delivery57571.0057Vertor et delivery5830.43 (0.22-1.03)0.0580.40 (0.18-0.87)0.021Casection75 (0.04)830.48 (0.22-1.03)0.0580.40 (0.18-0.87)0.021Married/Union120 (0.05)830.011.000.010.01Married/Union3421 (93.8)36491.66 (1.19-2.31)1.00 (0.62-0.94)0.490Moreducation54 (94.4)5761.88 (1.18-3.00)0.0061.50 (0.56-4.00)0.490Moreducation19731.001.011.011.011.01Prinary194 (9.05)19731.00 (0.62-1.93)0.0211.50 (0.56-4.01)0.490Moreducation19731.001.001.50 (0.56-4.01)0.4900.490Prinary194 (9.05)1.9131.00 (0.62-1.93)1.50 (0.56-4.01)1.50 (0.56-4.01)0.490Moreducation194 (9.03)1.011.011.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01)1.50 (0.56-4.01) <td>1 to 2</td> <td>148 (95.5)</td> <td>155</td> <td>1.00</td> <td></td> <td></td> <td></td>	1 to 2	148 (95.5)	155	1.00			
Place of deliveryI Adah centre1458 (95.0)135.01.00Home/way to hospital69 (93.2)740.37 (0.29-1.86)0.507J TurneJ1458 (95.2)1.010.507J Atural1453 (95.2)1.5270.010.01C-Section7 (90.4)830.48 (0.22-1.03)0.0580.40 (0.18-0.87)J C-Section7 (90.4)830.48 (0.22-1.03)0.0580.40 (0.18-0.87)0.021J C-Section7 (90.4)830.011.000.01J C-Section424 (90.0)4711.001.001.00Married/Union421 (93.8)36491.66 (1.19-2.31)1.50 (0.76-2.94)0.490J Toirced/Separated540 (4.4)5761.88 (1.18-3.00)0.0061.50 (0.56-4.00)0.490Moreid/C-Moreid183 (93.1)19731.001.50 (0.56-4.00)0.490Moreid/Separated183 (93.1)19731.001.50 (0.56-4.00)0.491Primary194 (93.6)19731.00 (0.51-3.91)1.51 (1.	3 or above	1380 (94.8)	1455	0.87 (0.39-1.92)	0.731		
Health centre1458 (95.0)15351.00Home/way to hospital69 (93.2)74 (0.32) (3.2) (3.2)0.507Ty-or deliveryT1.011.00Ty-or delivery1.5271.000.5080.40 (0.18-0.87) (0.2)C-Section75 (90.4)830.48 (0.22-1.03)0.5880.40 (0.18-0.87) (0.2)C-Section75 (90.4)830.48 (0.22-1.03)0.580.40 (0.18-0.87) (0.2)Married/Valion424 (90.0)811.001.001.00Married/Valion424 (90.0)6491.66 (1.19-2.31)1.50 (0.76-2.94)Nored/Separated54 (94.4)5761.88 (1.18-3.00)0.0061.50 (0.56-4.00)0.490Married/Valion183 (93.1)19731.001.50 (0.56-4.00)0.491Moducation183 (93.1)19731.001.50 (0.56-4.00)0.491Morady or higher194 (93.6)12131.001.50 (0.56-4.00)0.491Morady or higher194 (93.6)1.03 (0.86-2.09)0.4211.50 (0.56-4.00)1.50 (0.56-4.00)Morady or higher194 (93.6)1.31 (0.86-2.09)0.4211.50 (0.56-4.00)1.50 (0.56-4.00)1.50 (0.56-4.00)Morady or higher1.90 (9.51-3.9)1.90 (0.85-1.39)1.90 (0.85-1.39)1.90 (0.85-1.39)1.90 (0.85-1.39)Morady or higher1.93 (9.61)1.90 (0.85-1.39)1.91 (0.91 (Place of delivery						
Home/way to hospital69 (93.2)740.73 (0.29-1.86)0.507Jutral1453 (95.2)15271.001.00C-Section75 (90.4)830.48 (0.22-1.03)0.0580.40 (0.18-0.87)0.021Jutral's marital status550.48 (0.22-1.03)0.0580.40 (0.18-0.87)0.021Juine' Married/Union424 (90.0)4711.001.001.001.00Married/Union421 (93.8)36491.66 (1.19-2.31)1.00 (0.56-0.00)0.493Jourced/Separated54 (94.4)5761.88 (1.18-3.00)0.0661.50 (0.56-4.00)0.494Jutre's education1194 (93.6)19731.001.50 (0.56-4.00)0.494Married/Union1836 (93.1)19731.001.50 (0.56-4.00)0.494Jutre's education1194 (93.6)1.011.50 (0.56-4.00)0.494Jutre's education11.91 (0.56-1.39)1.91 (0.56-1.39)1.91 (0.56-1.39)1.91 (0.56-1.39)Jutre's religion11.03 (0.86-2.09)0.4211.51 (0.56-1.50)1.51 (0.56-1.50)1.51 (0.56-1.50)Inter's religion11.92 (0.56-1.39)1.33 (0.86-2.09)0.4211.51 (0.56-1.50)1.51 (0.56-1.50)Inter's religion11.92 (0.56-1.50)1.92 (0.56-1.50)1.92 (0.56-1.50)1.92 (0.56-1.50)1.92 (0.56-1.50)Inter's religion11.92 (0.56-1.50)1.92 (0.56-1.50)1.92 (0.56-1.50)1.92 (0.56-1.50)1.92 (0.56-1.50)Inter's religion<	Health centre	1458 (95.0)	1535	1.00			
Type of deliveryNatural1453 (95.2)15271.001.00C-Section76 (9.0.4)830.48 (0.22-1.0.3)0.0580.40 (0.18-0.87)0.021N=ture's marital statusNo1.001.00No1.00Married/Union424 (90.0)4711.001.001.00Married/Union3421 (93.8)36491.66 (1.19-2.31)1.50 (0.76-2.94)0.490Jourced/Separated544 (94.0)5761.88 (1.18-3.00)0.0061.50 (0.56-4.00)0.490Jourced/Separated1836 (9.3.1)19731.001.50 (0.56-4.00)0.491Jourced/Separated1836 (9.3.1)19731.001.50 (0.56-4.00)0.491Jourced/Separated1836 (9.3.1)19731.001.50 (0.56-4.00)0.491Jourced/Separated1836 (9.3.1)19731.001.50 (0.56-4.00)0.491Jourced/Separated1836 (9.3.1)19731.001.50 (0.56-4.00)0.491Jourced/Separated1836 (9.3.1)19731.30 (0.85-1.39)1.51 (0.56-4.00)1.50 (0.56-4.00)Jourced/Separated194 (9.3.6)19731.33 (0.86-2.09)0.4211.51 (0.56-4.00)1.51 (0.56-4.00)Jourced/Separated190 (0.51-3.91)1.33 (0.86-2.09)0.4211.51 (0.56-4.00)1.51 (0.56-4.00)Jourced/Separated183 (9.3.0)1.63 (0.30)1.51 (0.56-4.00)1.51 (0.56-4.00)1.51 (0.56-4.00)Jourced/Separated190 (0.51-3.91)1.51 (0.56-4.00)1.51 (0.56	Home/way to hospital	69 (93.2)	74	0.73 (0.29-1.86)	0.507		
Natural1453 (95.2)15271.001.00C-Section76 (90.4)830.48 (0.22-1.03)0.0580.40 (0.18-0.87)0.021M-tret's marital status51.001.001.001.00Married/Union424 (90.0)4711.001.001.50 (0.76-2.94)I hored/Separated342 (93.8)36491.66 (1.19-2.31)1.50 (0.56-4.00)0.490I hored/Separated54 (94.4)5761.88 (1.18-3.00)0.0061.50 (0.56-4.00)0.490I hored/Separated1836 (93.1)19731.001.50 (0.56-4.00)0.491Primary194 (93.6)19731.001.50 (0.56-4.00)0.491I hored/Separated194 (93.6)1.011.50 (0.56-4.00)0.491I hored/Separated194 (93.6)1.011.50 (0.56-4.00)0.491I hored/Separated1.021.011.50 (0.56-4.00)0.491I hored/Separated1.91 (0.56-4.00)0.411.50 (0.56-4.00)0.491I hored/Separated1.91 (0.56-4.00)0.4211.50 (0.56-4.00)1.50 (0.56-4.00)I hored/Separated1.91 (0.56-4.00)0.4211.50 (0.56-4.00)1.50 (0.56-4.00)I hored/Separated1.91 (0.56-4.00)0.4211.50 (0.56-4.00)1.50 (0.56-4.00)I hored/Separated1.91 (0.56-4.00)0.4211.50 (0.56-4.00)1.50 (0.56-4.00)I hored/Separated1.91 (0.56-4.00)1.91 (0.56-4.00)1.50 (0.56-4.00)1.50 (0.56-4.00)I hored/Separate1.91 (0.56-4.	Type of delivery						
C-Section75 (90.4)830.48 (0.22-1.03)0.0580.40 (0.18-0.87)0.021Jorder's maital statusSingle424 (90.0)4711.001.001.00Married/Union3421 (93.8)36491.66 (1.19-2.31)1.50 (0.76-2.94)0.490Joroced/Separated544 (94.4)5761.88 (1.18-3.00)0.0061.50 (0.56-4.00)0.490No education546 (93.1)19731.001.50 (0.56-4.00)0.491Primary1936 (93.1)19731.001.50 (0.56-4.00)5.40Joroced/Separated19311.09 (0.85-1.39)1.51 (0.56-4.00)5.40Primary1994 (93.6)5761.33 (0.86-2.09)0.4211.51 (0.56-4.00)Noter's religion1.60 (1.19)1.33 (0.86-2.09)0.4211.51 (0.56-4.00)Marter's religion1.61 (1.19)1.61 (1.19)1.61 (1.19)Indiana1.83 (1.93.4)1.9641.001.51 (1.19)	Natural	1453 (95.2)	1527	1.00		1.00	
Jingle 424 (90.0) 471 1.00 1.00 Married/Union 342 (93.0) 3649 1.66 (1.19-2.31) 1.50 (0.76-2.94) Divorced/Separated 544 (94.4) 576 1.88 (1.18-3.00) 0.006 1.50 (0.56-4.00) 0.490 M-ther's education 576 1.88 (1.18-3.00) 0.006 1.50 (0.56-4.00) 0.490 M o education 1836 (93.1) 1973 1.00 1.50 (0.56-4.00) 0.490 Primary 194 (93.6) 1973 1.00 1.50 (0.56-4.00) 0.490 Scondary or higher 430 (74.7) 576 1.30 (0.85-1.39) 1.421 1.50 (0.56-4.00) 1.50 (0.56-4.00) M-ther's religion 1094 (93.6) 1973 1.00 1.50 (0.56-4.00) 1	C-Section	75 (90.4)	83	0.48 (0.22-1.03)	0.058	0.40 (0.18-0.87)	0.021
Single 424 (90.0) 471 1.00 1.00 Married/Union 3421 (93.8) 3649 1.66 (1.19-2.31) 1.50 (0.76-2.94) Divorced/Separated 544 (94.4) 576 1.88 (1.18-3.00) 0.006 1.50 (0.56-4.00) 0.490 Her's education 1973 1.00 1.00 1.00 1.00 Primary 1994 (93.6) 1973 1.09 (0.85-1.39) 1.21 1.21 1.21 Secondary or higher 430 (74.7) 576 1.33 (0.86-2.09) 0.421 1.21 1.21 Metric's religion 1834 (93.4) 1964 1.00 1.01 1.01 1.01	Mother's marital status						
Married/Union 3421 (93.8) 3649 1.66 (1.19-2.31) 1.50 (0.76-2.94) Divorced/Separated 544 (94.4) 576 1.88 (1.18-3.00) 0.006 1.50 (0.56-4.00) 0.490 Morther's education No education 1836 (93.1) 1973 1.00 1.50 (0.76-2.94) 1.490 Primary 1936 (93.1) 1973 1.00 1.50 (0.76-2.94) 1.490 Secondary or higher 1934 (93.6) 1973 1.00 1.50 (0.76-2.94) 1.490 Morther's religion 1994 (93.6) 1973 1.00 1.421 1.50 (0.76-2.94) 1.490 Morther's religion 1994 (93.6) 1973 1.00 1.421 1.50 (0.76-2.94) 1.50 (0.76-2.94) Morther's religion 1994 (93.6) 1310 1.00 (0.85-1.39) 0.421 1.50 (0.76-2.94) 1.50 (0.76-2.94)	Single	424 (90.0)	471	1.00		1.00	
Divorced/Separated 544 (94.4) 576 1.88 (1.18-3.00) 0.006 1.50 (0.56-4.00) 0.490 Mother's education No education 1836 (93.1) 1973 1.00 Image: Comparate of the second	Married/Union	3421 (93.8)	3649	1.66 (1.19-2.31)		1.50 (0.76-2.94)	
No education 1836 (93.1) 1973 1.00 Primary 1994 (93.6) 2131 1.09 (0.85-1.39) Secondary or higher 430 (74.7) 576 1.33 (0.86-2.09) 0.421 Nutrer's religion 1944 (93.4) 1964 1.00 1.00	Divorced/Separated	544 (94.4)	576	1.88 (1.18-3.00)	0.006	1.50 (0.56-4.00)	0.490
No education 1836 (93.1) 1973 1.00 Primary 1994 (93.6) 2131 1.09 (0.85-1.39) Secondary or higher 430 (74.7) 576 1.33 (0.86-2.09) 0.421 Nother's religion 1944 (93.4) 1964 1.00 1.00	Mother's education						
Primary 1994 (93.6) 2131 1.09 (0.85-1.39) Secondary or higher 430 (74.7) 576 1.33 (0.86-2.09) 0.421 Mother's religion Christian 1834 (93.4) 1964 1.00	No education	1836 (93.1)	1973	1.00			
Secondary or higher 430 (74.7) 576 1.33 (0.86-2.09) 0.421 Mother's religion Christian 1834 (93.4) 1964 1.00	Primary	1994 (93.6)	2131	1.09 (0.85-1.39)			
Mother's religionChristian1834 (93.4)19641.00	Secondary or higher	430 (74.7)	576	1.33 (0.86-2.09)	0.421		
Christian 1834 (93.4) 1964 1.00	Mother's religion						
	Christian	1834 (93.4)	1964	1.00			

Table 4 Analysis of factors associated to a adequate timeliness of BCG administration (within 28 first days of life) according to health card

Variable	Timely BCG	Total	Bivariate analysis		Multivariable analys	is
	vaccinated (%)	children with BCG	OR (95%CI)	<i>p</i> -value	OR (95%CI)	<i>p</i> -value
Muslim	35 (89.7)	39	0.62 (0.22-1.77)			
Traditional African	1907 (94.2)	2025	1.15 (0.89-1.48)			
Others	376 (93.3)	403	0.99 (0.64-1.52)	0.528		
Distance to health centre						
Less than 5 km	61 (72.6)	84	1.00		1.00	
More than 5 km	205 (5.9)	3495	1.24 (0.92-1.66)	0.161	1.48 (0.90-2.44)	0.118

Table 4 Analysis of factors associated to a adequate timeliness of BCG administration (within 28 first days of life) according to health card (*Continued*)

whose adults were present at the moment of the interview and presented the card (for evaluation of the registration) and/or the children were present (for scar assessment). There were 16.9% (1609/9512) of children who did not present a health card. Although most of them argued that adults had lost the card, these children might live in families with more difficulties in accessing the health system or not able to have a proper follow-up of their children's health status, thus our vaccination coverage could be overestimating the real one. Secondly, children who died before the first round visit were not included and might have different (potentially lower) vaccine coverage. Thirdly, given the discrepancies found about BCG vaccination assessed through health card and presence of scar, poor BCG documentation in the card or poor evaluation of BCG scar, cannot be ruled out. Last, due to the low number of non-vaccinated individuals identified, the study had little power to detect potential factors associated with absence of vaccination.

Conclusions

This study shows high vaccination coverage in Manhica district; although vaccines that need several doses or that are administered months after birth require larger efforts to ensure all children are properly and completely vaccinated. The vast majority of BCG vaccines are given within the first days after birth. Scar development occurs in almost all infants. No associations with lack of BCG were found, except for living in the municipality of Maluana. These findings require targeted investigations to find out potential reasons for that difference in coverage that might benefit from tailored interventions. Prospective data collection at the time of vaccination would avoid potential bias inherent to retrospective data collection. This research study, beyond high coverage of BCG and other EPI vaccines, shows the importance of having data registries in LMIC to monitor health systems' performance, resource allocation planning and progress in immunization strategies.

Additional file

Additional file 1: Demographic and socioeconomic characteristics of less than 36-months old children with and without card. In this table we expand the baseline demographic and socioeconomic characteristics of study participants depending on the availability of the health card. (DOCX 19 kb)

Abbreviations

AIDS: Acquired immune deficiency syndrome; BCG: Bacille Calmette-Guérin; CI: Confidence interval; CISM: Centro de Investigação em Saúde de Manhiça; DPT/HepB/hib: Diphtheria Pertussis Tetanus/Hepatitis B/Haemophilus influenza type b (pentavalent vaccine); DSS: Demographic surveillance system; EPI: Expanded programme on immunization; HDSS: Health and demographic surveillance system; HIV: Human immunodeficiency virus; LIC: Low income Countries; LMIC: Low and middle income Countries; OPV: Oral polio vaccine; OR: Odds ratio; TB: Tuberculosis; TST: Tuberculin skin test; WHO: World Health Organization

Acknowledgements

This analysis is the outcome of EMC's end of Masters' project at MSc Clinical Research (International Health track). The authors of this study would like to thank all the families in the district of Manhiça. We also want to thank the staff at CISM's Demography department for their support in data collection. We thank the National Tuberculosis Program staff and District Health Authorities for their constant support. This work was been partially supported by the Ensure Mundue, leint Dectants Program of the European Union through a

the Erasmus Mundus Joint Doctorate Program of the European Union through a training grant to ALGB. ISGlobal is a member of the CERCA Programme, Generalitat de Catalunya.

Funding

No external funding was needed for this study.

Availability of data and materials

An anonymized dataset can be made available to interested researchers after a formal request to CISM's Internal Scientific Committee (cci@manhica.net).

Authors' contributions

ALGB, CS conceived the study. AN, EJ, CS, participated in data collection. JJA and OJA participated in data management and design of forms for data collection. EMC, AN, CS, ALGB conducted the analysis. AC provided statistical support. EMC, EM, BS, QB, ELV, ALGB, ELV contributed to data interpretation. ALGB, BS, EM provided direction throughout the research process. All authors have been involved in drafting the manuscript. All authors approved the last version as sent to the journal.

Ethics approval and consent to participate

This study was approved by the Centro de Investigação em Saúde de Manhiça's (CISM, from its acronym in Portuguese) Internal Scientífic Committee. Heads of households in the area under demographic surveillance provide a written informed consent allowing to use data collected by the HDSS for research purposes. The study was conducted following the principles of the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Author details

¹ISGlobal, Barcelona Ctr. Int. Health Res. (CRESIB), Hospital Clínic-Universitat de Barcelona, C/Rosselló 132, 08036 Barcelona, Spain. ²Centro de Investigação em Saúde da Manhiça (CISM), Rua 12, Vila de Manhiça, CP 1929 Maputo, Mozambique. ³ICREA, Pg. Lluís Companys 23, 08010 Barcelona, Spain. ⁴Amsterdam Institute for Global Health and Development (AIGHD), Amsterdam, The Netherlands.

Received: 31 March 2017 Accepted: 23 January 2018 Published online: 13 February 2018

References

- WHO. Global Tuberculosis Report 2015 [Available from: http://apps.who.int/ iris/bitstream/10665/191102/1/9789241565059_eng.pdf.
- Roth A, Garly ML, Jensen H, Nielsen J, Aaby P. Bacillus Calmette-Guerin vaccination and infant mortality. Exp Rev Vaccines. 2006;5(2):277–93.
- Montagnani C, Chiappini E, Galli L, de Martino M. Vaccine against tuberculosis: what's new? BMC Infect Dis. 2014;14(Suppl 1):S2.
- Van-Dunem JC, Rodrigues LC, Alencar LC, Militao-Albuquerque Mde F, Ximenes RA. Effectiveness of the first dose of BCG against tuberculosis among HIV-infected, predominantly immunodeficient children. Biomed Res Int. 2015;275029.
- Dhanawade SS, Kumbhar SG, Gore AD, Patil VN. Scar formation and tuberculin conversion following BCG vaccination in infants: a prospective cohort study. J Family Med Prim Care. 2015;4(3):384–7.
- Abubakar I, Pimpin L, Ariti C, Beynon R, Mangtani P, Sterne JA, et al. Systematic review and meta-analysis of the current evidence on the duration of protection by bacillus Calmette-Guerin vaccination against tuberculosis. Health Technol Assess. 2013;17(37):1–372. v-vi
- Roy A, Eisenhut M, Harris RJ, Rodrigues LC, Sridhar S, Habermann S, et al. Effect of BCG vaccination against mycobacterium tuberculosis infection in children: systematic review and meta-analysis. BMJ (Clinical research ed). 2014;349:g4643.
- WHO. Systematic review of the non-specific effects of BCG, DTP and measles containing vaccines. 2014. [Available from: http://www.who.int/ immunization/sage/meetings/2014/april/3_NSE_Epidemiology_review_ Report_to_SAGE_14_Mar_FINAL.pdf].
- Nguipdop-Djomo P, Heldal E, Rodrigues LC, Abubakar I, Mangtani P. Duration of BCG protection against tuberculosis and change in effectiveness with time since vaccination in Norway: a retrospective population-based cohort study. Lancet Infect Dis. 2016;16(2):219–26.
- Storgaard L, Rodrigues A, Martins C, Nielsen BU, Ravn H, Benn CS, et al. Development of BCG scar and subsequent morbidity and mortality in rural Guinea-Bissau. Clin Infect Dis. 2015;61(6):950–9.
- Roth A, Gustafson P, Nhaga A, Djana Q, Poulsen A, Garly ML, et al. BCG vaccination scar associated with better childhood survival in Guinea-Bissau. Int J Epidemiol. 2005;34(3):540–7.
- Consonni D, Montenegro Agorostos Karagianis MM, Bufardeci G. Immunisation with BCG in the Maringue District, Sofala Province, Mozambique. Tuberc Res Treat. 2013;2013:312065.
- Pang Y, Kang W, Zhao A, Liu G, Du W, Xu M, et al. The effect of bacille Calmette-Guerin vaccination at birth on immune response in China. Vaccine. 2015;33(1):209–13.
- Animaw W, Taye W, Merdekios B, Tilahun M, Ayele G. Expanded program of immunization coverage and associated factors among children age 12-23 months in Arba Minch town and Zuria District, southern Ethiopia, 2013. BMC Public Health. 2014;14:464.
- Le Polain de Waroux O, Schellenberg JR, Manzi F, Mrisho M, Shirima K, Mshinda H, et al. Timeliness and completeness of vaccination and risk factors for low and late vaccine uptake in young children living in rural southern Tanzania. Int Health. 2013;5(2):139–47.

- Scott S, Odutola A, Mackenzie G, Fulford T, Afolabi MO, Lowe Jallow Y, et al. Coverage and timing of children's vaccination: an evaluation of the expanded programme on immunisation in the Gambia. PLoS One. 2014;9(9):e107280.
- Fadnes LT, Jackson D, Engebretsen IM, Zembe W, Sanders D, Sommerfelt H, et al. Vaccination coverage and timeliness in three south African areas: a prospective study. BMC Public Health. 2011;11:404.
- Canavan ME, Sipsma HL, Kassie GM, Bradley EH. Correlates of complete childhood vaccination in east African countries. PLoS One. 2014;9(4):e95709.
- Schoeps A, Ouedraogo N, Kagone M, Sie A, Muller O, Becher H. Sociodemographic determinants of timely adherence to BCG, Penta3, measles, and complete vaccination schedule in Burkina Faso. Vaccine. 2013;32(1):96–102.
- Gram L, Soremekun S, ten Asbroek A, Manu A, O'Leary M, Hill Z, et al. Socioeconomic determinants and inequities in coverage and timeliness of early childhood immunisation in rural Ghana. Tropical Med Int Health. 2014;19(7):802–11.
- Gidado S, Nguku P, Biya O, Waziri NE, Mohammed A, Nsubuga P, et al. Determinants of routine immunization coverage in Bungudu, Zamfara state, northern Nigeria, may 2010. Pan Afr Med J. 2014;18(Suppl 1):9.
- 22. Thysen SM, Byberg S, Pedersen M, Rodrigues A, Ravn H, Martins C, et al. BCG coverage and barriers to BCG vaccination in Guinea-Bissau: an observational study. BMC Public Health. 2014;14:1037.
- Odusanya OO, Alufohai EF, Meurice FP, Ahonkhai VI. Determinants of vaccination coverage in rural Nigeria. BMC Public Health. 2008;8:381.
- 24. Thorpe S, VanderEnde K, Peters C, Bardin L, Yount KM. The influence of Women's empowerment on child immunization coverage in low, lowermiddle, and upper-middle income countries: a systematic review of the literature. Matern Child Health J. 2016;20(1):172–86.
- Garcia-Basteiro AL, Lopez-Varela E, Respeito D, Gonzalez R, Naniche D, Manhica I, et al. High tuberculosis burden among people living with HIV in southern Mozambique. Eur Respir J. 2015;45(2):547–9.
- 26. Garcia-Basteiro AL, Respeito D, Augusto OJ, Lopez-Varela E, Sacoor C, Sequera VG, et al. Poor tuberculosis treatment outcomes in southern Mozambique (2011-2012). BMC Infect Dis. 2016;16:214.
- Ministry of Health, Republic of Mozambique. National Immunization Plan. Comprehensive Multi-Year Plan (cMYP) 2012-2016. Available at http://www. nationalplanningcycles.org/sites/default/files/planning_cycle_repository/ mozambique/mozambique_cmyp_2012-2016_.pdf.
- WHO. The Global Summary Monitoring System for Vaccine Preventable Diseases. 2016. [Available from: http://apps.who.int/immunization_ monitoring/globalsummary].
- 29. Lanaspa M, Balcells R, Sacoor C, Nhama A, Aponte JJ, Bassat Q. The performance of the expanded programme on immunization in a rural area of Mozambique. Acta Trop. 2015;149:262–6.
- Marais BJ, Seddon JA, Detjen AK, van der Werf MJ, Grzemska M, Hesseling AC, et al. Interrupted BCG vaccination is a major threat to global child health. Lancet Respir Med. 2016;4(4):251–3.
- Sacoor C, Nhacolo A, Nhalungo D, Aponte JJ, Bassat Q, Augusto O, et al. Profile: Manhica health research centre (Manhica HDSS). Int J Epidemiol. 2013;42(5):1309–18.
- Gonzalez R, Munguambe K, Aponte J, Bavo C, Nhalungo D, Macete E, et al. High HIV prevalence in a southern semi-rural area of Mozambique: a community-based survey. HIV medicine. 2012;13(10):581–8.
- 33 García-Basteiro AL, Miranda Ribeiro R, Brew J, Sacoor C, Valencia S, Bulo H, Cobelens F, Macete E. Tuberculosis on the rise in southern Mozambique (1997-2012). Eur Respir J. 2017;49(3).
- Timaeus I, Garaham W. Measuring adult mortality in developing countries: a review and assessment of methods. Population, Health, and Nutridon Division, Population and Human Resources Department. World Bank; 1988. Available at: http://documents.worldbank.org/curated/en/ 386261468765039030/pdf/multi0page.pdf.
- Lopez-Varela E, Augusto OJ, Guerra L, Respeito D, Sacor C, Sacarlal J, et al. Low paediatric tuberculosis case detection rate in southern Mozambique. Eur Respir J. 2016;47(3):1003–5.
- Lopez-Varela E, Augusto OJ, Gondo K, Garcia-Basteiro AL, Fraile O, Ira T, et al. Incidence of tuberculosis among young children in rural Mozambique. Pediatr Infect Dis J. 2015;34(7):686–92.
- 37. Vyas S, Kumaranayake L. Constructing socio-economic status indices: how to use principal components analysis. Health Policy Plan. 2006;21(6):459–68.
- A Prospective Study of Bacillus Calmette-Guérin Scar Formation and Tuberculin Skin Test Reactivity in Infants in Lima, Peru. Pediatrics. 2003;112(4):e298.

- Santiago EM, Lawson E, Gillenwater K, Kalangi S, Lescano AG, Du Quella G, et al. A prospective study of bacillus Calmette-Guerin scar formation and tuberculin skin test reactivity in infants in lima. Peru Pediatrics. 2003;112(4):e298.
- Timmermann CA, Biering-Sorensen S, Aaby P, Fisker AB, Monteiro I, Rodrigues A, et al. Tuberculin reaction and BCG scar: association with infant mortality. Tropical Med Int Health. 2015;20(12):1733–44.

Submit your next manuscript to BioMed Central and we will help you at every step:

- We accept pre-submission inquiries
- Our selector tool helps you to find the most relevant journal
- We provide round the clock customer support
- Convenient online submission
- Thorough peer review
- Inclusion in PubMed and all major indexing services
- Maximum visibility for your research

Submit your manuscript at www.biomedcentral.com/submit

