INTRODUCTION
Transmission of tuberculosis (TB) in healthcare settings, to both patients and healthcare workers (HCWs), is a global problem. Poor implementation of infection control measures, the effects of the Human Immunodeficiency Virus (HIV) epidemic on TB, and the emergence of multidrug-resistant strains has resulted in the re-emergence of hospital-based transmission of TB. In high TB burden countries, HCWs have an increased risk of acquiring TB as they are exposed to TB in their communities as well as at their workplaces. TB was the third most common occupational disease reported to the Compensation Commissioner in South Africa (SA) in 2006. South Africa continues to have one of the highest burdens of TB globally with over 689 cases per 100 000 population reported in 2013. The incidence of TB varies across the provinces in SA, and KwaZulu-Natal (KZN) consistently had a higher annual incidence risk (IR) with 902 cases notified per 100 000 population in 2013. In that year, the eThekwini Health District (EHD) in KZN reported the second highest IR of TB (1 032 cases per 100 000 population) out of the 52 health districts in SA. This high TB incidence reflects the high HIV prevalence in the province.

The South African National Tuberculosis Programme identified HCWs as a high risk population for developing TB, together with miners and prisoners. Although local epidemiological studies are limited, they suggest an increase in incidence and rising occupational risk of acquiring TB among HCWs. Despite occupational health legislation and policy provisions, the current framework for dealing with occupational TB remains fragmented. HCWs in resource-limited settings, including SA, are often poorly equipped to meet the demands placed on them by the TB burden. Few studies have reported on the incidence of TB among HCWs in South Africa in the last 20 years. The most recent study conducted in EHD in KZN reported a mean TB IR of 1 133 cases per 100 000 HCWs from 1999 to 2004. The aim of the current study was to measure the IR of TB disease among HCWs, to investigate factors associated with acquiring TB in these HCWs, and to compare the incidence of TB among HCWs with that in the general, provincial and district populations from 2006 to 2010.

METHODS
The EHD, which has 16 public sector hospitals and eight community health centres, was chosen as the study site due to its high burden of TB disease provincially and nationally. HCWs with suspected TB should be screened, diagnosed and treated...
at the healthcare facility’s occupational health clinic. Data on HCWs who are diagnosed with TB at these occupational health clinics should be submitted to the office of the Compensation Commissioner in terms of the Compensation for Occupational Injuries and Diseases Act.³

A retrospective review of the occupational health clinic TB registers, for the period January 2006 to December 2010, was conducted at hospitals and community health centres in the EHD. Five hospitals and four community health centres were excluded from the study as they did not have occupational health services during the study period. HCWs from these facilities sought healthcare services from their local public clinic or hospital, or from a private practitioner. The study sample included only HCWs with TB recorded in the occupational health clinic register in healthcare facilities with occupational health services. The number of facilities recording HCWs with TB increased from six to 15 during the study period.

Trained fieldworkers collected patients’ demographic, occupational and clinical data from the TB registers, using a standardised data-capturing tool. The number of HCWs employed annually and their work categories at each facility were provided by the KZN Department of Health. Healthcare workers included all persons employed to work in the healthcare facilities during the study period.

Data was processed and analysed using Stata Version 13. The IR for TB was calculated as the number of cases of TB per year among HCWs per total number of HCWs employed during that year, for each facility. In bivariate analysis, the Chi-square test was used to test for significant relationships between sex, age group and occupation, and having a diagnosis of TB. Multivariate analysis (Poisson regression) was utilised to adjust for the influence of covariates and to calculate the IRR and 95% confidence intervals. The mean IR for age groups and occupational categories was compared using analysis of variance (ANOVA). The level of significance was set at 0.05. A self-selection multivariable model building approach (bivariate regressions with a p-value of <0.1), including age and gender, was used in the final multivariable model. The level of significance used for interpretation of the data was 0.05. The annual IR for TB among HCWs was compared to that for the general population obtained from published TB reports.⁴,¹⁰

Permission to conduct the research was obtained from the KwaZulu-Natal Research and Ethics Committee and each of the healthcare facilities. The study was approved by the Biomedical Research Ethics Committee at the University of KwaZulu-Natal (BE305/12).

### RESULTS

Six hundred and eighteen HCWs were diagnosed with TB from 2006 to 2010. The median age of the 358 (57.9%) HCWs who had age recorded was 37 years (range 20 – 63 years) and the majority (73.8%) were female (Table 1). The age and gender profiles were in keeping with the profiles of HCWs employed at these facilities during the study period (data not shown). Throughout the five-year period, nurses comprised just less than half (44.3%) of HCWs with TB, followed by support and administrative staff (34.8%).

Eighty-six percent of HCWs presented with pulmonary TB followed by pleural TB (Figure 1), and most (n=546, 81.3%) had no previous history of TB.

The proportion of HCWs with multidrug resistant-TB (MDR-TB) ranged from 7.4% to 10.1% of the TB cases per year. Only 20.6% of HCWs were recorded as having been tested for HIV; of those, 65 (51.2%) were HIV positive.

The incidence of TB in HCWs ranged from 783 to 1 081 per 100 000 (Table 2), with a mean of 908 cases (95% CI 771 – 1 046) per 100 000.

### Table 1. Summary of HCWs diagnosed with TB in EHD, 2006 – 2010

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilities reporting TB cases (n)</td>
<td>6</td>
<td>9</td>
<td>12</td>
<td>14</td>
<td>15</td>
<td>67</td>
</tr>
<tr>
<td>HCWs employed in facilities reporting TB (n)</td>
<td>7 384</td>
<td>12 007</td>
<td>14 348</td>
<td>16 838</td>
<td>16 985</td>
<td>67 562</td>
</tr>
<tr>
<td>TB cases reported (n)</td>
<td>69</td>
<td>94</td>
<td>126</td>
<td>182</td>
<td>147</td>
<td>618</td>
</tr>
<tr>
<td>Female HCWs with TB (n; %)</td>
<td>48; 69.6</td>
<td>72; 76.6</td>
<td>93; 73.8</td>
<td>135; 74.2</td>
<td>108; 73.5</td>
<td>456; 73.8</td>
</tr>
</tbody>
</table>

### Table 2. Annual TB incidence risk, 2006 - 2010

<table>
<thead>
<tr>
<th>Year</th>
<th>IR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>934</td>
<td>714-153</td>
</tr>
<tr>
<td>2007</td>
<td>783</td>
<td>652-940</td>
</tr>
<tr>
<td>2008</td>
<td>878</td>
<td>732-1 040</td>
</tr>
<tr>
<td>2009</td>
<td>1 081</td>
<td>935-1 250</td>
</tr>
<tr>
<td>2010</td>
<td>865</td>
<td>733-1 014</td>
</tr>
</tbody>
</table>

### Figure 1. Clinical presentation of TB among 618 HCWs in EHD, 2006 – 2010
The risk of TB among male HCWs was 20% higher (adjusted IRR 1.2, 95% CI: 0.9-1.6, p=0.229) than in females. Paramedical and support/administrative staff had the highest risk for having TB compared to nurses (adjusted IRR 2.3, 95%CI: 1.4-3.7, p<0.001; and (adjusted IRR 1.6, 95% CI: 1.2 – 2.1, p<0.000, respectively). Public sector doctors reporting to occupational health clinics at these facilities had a lower risk for TB than nurses (adjusted IRR 0.6, 95% CI: 0.2-1.0, p=0.056). Healthcare workers aged 35 to 44 years had the highest TB risk relative to those younger than 25 (adjusted IRR 1.4, 95% CI: 0.8 – 2.5, p=0.260) (Table 3).

TB treatment outcomes were recorded in 564 (91.2%) HCWs over the five-year period. Only 109 (19.3%) were cured but 422 (74.8%) completed treatment during this period. The best outcomes were reported in 2009 when 155 (95.7%) of those with an outcome recorded successfully completed treatment. The case-fatality ranged from 3.5% to 10.8%. (Figure 2).

HCWs in this district had a higher IR of TB than the South African population for each year from 2006 to 2010 (Figure 3), but a lower IR when compared with the general population in KZN and EHD. The IR in both the HCWs and the general populations showed a year-on-year increasing trend during the study period.

**DISCUSSION**

The mean IR of TB among HCWs in EHD for the five-year study period (908 cases per 100 000, 95% CI: 771-1 045, range 783 to 1 081) was comparable to the global annual IR of 1 180 per 100 000 (IQR 910 – 3 222) from high TB incidence countries. 1

### Table 3. Association of TB with sex, occupational category and age in HCWs in EHD, 2006 – 2010

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>HCWs at risk (n)</th>
<th>IR</th>
<th>95% CI</th>
<th>Crude IRR 95% CI</th>
<th>p value</th>
<th>Adjusted IRR</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>494</td>
<td>51 045</td>
<td>885</td>
<td>735-1 035</td>
<td>1.1</td>
<td>0.9-1.3</td>
<td>0.192</td>
<td>1.2</td>
<td>0.9-1.6</td>
</tr>
<tr>
<td>Male</td>
<td>179</td>
<td>16 517</td>
<td>958</td>
<td>808-1 109</td>
<td>Reference</td>
<td>1.1</td>
<td>0.192</td>
<td>1.2</td>
<td>0.9-1.6</td>
</tr>
<tr>
<td><strong>Occupational category</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurse</td>
<td>301</td>
<td>36 840</td>
<td>763</td>
<td>567-959</td>
<td>Reference</td>
<td>1.1</td>
<td>0.192</td>
<td>1.2</td>
<td>0.9-1.6</td>
</tr>
<tr>
<td>Doctor</td>
<td>23</td>
<td>5 235</td>
<td>358</td>
<td>63-653</td>
<td>0.5</td>
<td>0.3-0.8</td>
<td>0.002</td>
<td>0.6</td>
<td>0.2-1.0</td>
</tr>
<tr>
<td>Paramedical</td>
<td>37</td>
<td>3 857</td>
<td>717</td>
<td>59-1 375</td>
<td>1.2</td>
<td>0.8-1.7</td>
<td>0.449</td>
<td>2.3</td>
<td>1.4-3.7</td>
</tr>
<tr>
<td>Support &amp; administration#</td>
<td>235</td>
<td>21 042</td>
<td>1 018</td>
<td>776-1 259</td>
<td>1.4</td>
<td>1.1-1.6</td>
<td>0.031</td>
<td>1.6</td>
<td>1.2-2.1</td>
</tr>
<tr>
<td><strong>Age group (years)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>&lt; 25</td>
<td>15</td>
<td>3 953</td>
<td>351</td>
<td>294-407</td>
<td>Reference</td>
<td>1.1</td>
<td>0.192</td>
<td>1.2</td>
<td>0.9-2.8</td>
</tr>
<tr>
<td>25-34</td>
<td>126</td>
<td>18 792</td>
<td>603</td>
<td>326-880</td>
<td>1.8</td>
<td>1.0-3.0</td>
<td>0.028</td>
<td>1.6</td>
<td>0.9-2.8</td>
</tr>
<tr>
<td>35-44</td>
<td>143</td>
<td>19 250</td>
<td>650</td>
<td>267-1 033</td>
<td>1.9</td>
<td>1.2-3.3</td>
<td>0.008</td>
<td>1.4</td>
<td>0.8-2.5</td>
</tr>
<tr>
<td>45-54</td>
<td>85</td>
<td>16 639</td>
<td>462</td>
<td>179-745</td>
<td>1.3</td>
<td>0.8-2.3</td>
<td>0.289</td>
<td>1.0</td>
<td>0.5-1.8</td>
</tr>
<tr>
<td>55-64</td>
<td>24</td>
<td>7 959</td>
<td>257</td>
<td>38-476</td>
<td>0.8</td>
<td>0.4-1.5</td>
<td>0.485</td>
<td>0.6</td>
<td>0.3-1.0</td>
</tr>
</tbody>
</table>

# ward clerks, general orderlies and assistants, porters, cleaners, security guards, drivers and maintenance staff
IR: incidence risk, IRR: incidence risk ratio

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1. [No data for the incidence of TB within the eThekwini population were available for year one of the study (2006)]
During the study period, some other studies also reported the annual IR of TB in HCWs in SA. Claassens et al. measured the smear positive TB annual IR in 47 HCWs from 33 primary healthcare clinics in five provinces in SA. They reported an IR of 834 (95% CI: 431-1 457) in 2006, 1 092 (95% CI: 647-1 725) in 2007 and 887 (95% CI: 517-1 420) in 2008.10 Tudor et al. reported a much higher mean IR in 112 HCWs from three district hospitals in KZN from 2006 to 2010, viz. 1 958 per 100 000.11 This high IR was also reported in a national survey of 10 facilities in 2006 (IR 1 130 to 1 470 per 100 000).2 Our findings are most comparable to the previous study in EHD which reported an IRR of 1 133 per 100 000 population from 1999 to 2004; covering 583 HCWs in eight public health facilities.12

The mean IR for the entire study period was slightly lower than that reported for SA nationally (960 per 100 000 in 2008, 971 in 2009 and 981 in 2010).13 It was also lower than the IR reported for the KZN province (1 162 per 100 000) and EHD (1 212 per 100 000) in 2010.13

There are several possible explanations for the lower IR of TB among HCWs compared to the general population. First, TB among HCWs in this district might be under-reported in the public sector as HCWs might be diagnosed and receive treatment outside their work facilities and not included in the occupational health clinic records. Membership of the Government Employees’ Medical Scheme of South Africa has grown rapidly since its inception in 2005, and has resulted in large numbers of HCWs accessing private healthcare, especially in urban areas. Second, the rising incidence of TB in the general population—a 400% increase in TB incidence over the past 15 years—might result in an apparent lower incidence in HCWs.5 This is a likely scenario in the EHD which has one of the highest TB burdens nationally. Finally, HCWs might have better health, nutrition and access to care through initiatives by the Department of Health such as the Integrated Wellness and Healthy Lifestyle Programme that empowers HCWs to be aware of their HIV status, to develop healthy lifestyles, and to have uninterrupted access to treatment within their institutions.14

The incidence of TB was highest in the 35 to 44-years age group, which was similar to that reported in a systematic review by Grobler et al.2 However, a previous study in EHD reported the highest incidence in the 25 to 29-years age group.12 These studies highlight the burden of TB in relatively younger employees, which negatively affects the productivity of the healthcare workforce.

The high IR of TB (1 018 cases per 100 000) among support and administrative staff is of concern. These categories of staff are frequently the first point of contact with the health service for a TB patient, and their work area may be poorly ventilated and overcrowded. Support staff, which include cleaners, often work in close proximity to patients without any personal protective equipment. These categories of staff are often excluded from training on TB disease transmission and infection prevention and control measures.

The majority of HCWs (85.8%) were diagnosed with pulmonary TB; this is higher than the proportion reported in a previous EHD study (76.5%).12 The implications of this finding are unclear and need to be further investigated. It is possible that the increased uptake of antiretroviral therapy has changed the clinical manifestation of TB among HCWs.

The proportion of HCWs with MDR-TB (7.4% – 10.1%) was higher than that reported for SA as a whole (1.8% for new TB cases; 6.7% for re-treatment TB cases).15 The prevalence of MDR-TB reported in previous studies among HCWs in KZN ranged from 3.0% to 11.6% from 1999 to 2010.11,12 KZN is an MDR-TB hotspot that consistently reports proportions above the national average.16

Overall, treatment outcomes for smear-positive TB patients in SA continue to improve; the proportion of successful treatment outcomes increased from 50.8% in 2004 to 71.1% in 2009.14 Treatment outcomes are still far below the World Health Organization target of >85%16. Successful TB treatment outcomes of 94.1% were reported in this study. This shows a marked improvement from the 62.9% and 61.6% reported in previous studies of HCWs in EHD and KZN, respectively.11,12 This improvement could be ascribed to factors such as improved screening for TB for HCWs, improved support available to HCWs with TB, and the Healthy Lifestyle Initiative mentioned earlier.15

Only 20.6% of HCWs with TB in this study had their HIV status recorded. There is no comparison with previous studies. Despite interventions by the Department of Health for HCWs to voluntarily

“HCWs in resource-limited settings, including SA, are often poorly equipped to meet the demands placed on them by the TB burden.”
know their HIV status, the results of this initiative are poor, possibly due to the stigma of HIV which might prevent HCWs from seeking or accepting HIV testing. It is likely that more HCWs know their HIV status, but are not comfortable to disclose this to their colleagues or employer.

LIMITATIONS
Data were obtained from public sector healthcare facilities in one health district, which may not reflect the burden of TB amongst HCWs across the province of KZN. Many HCWs use private healthcare providers in this largely urban district, which could result in underestimates of the incidence of TB amongst HCWs. The quality of data obtained from record reviews was dependent upon the quality of record keeping by the occupational health staff. The lack of data on environmental and personal risk factors was a limitation of this study. Categorising support and administrative staff together limits the usefulness of some of the results. It is likely that the occupational exposures to TB for each of these staff categories are different.

CONCLUSION AND RECOMMENDATIONS
TB among HCWs remains an important health issue in EHD. This study identified high-risk categories of HCWs who need to be targeted for intensive education to improve TB awareness. At a district level, strategies to verify the data on TB in HCWs need to be explored. Improved surveillance for TB in HCWs is required, and the notification system for TB in HCWs requires strengthening and collaboration with the private sector.

Measures to prevent the transmission of TB from patients to all categories of HCWs must be strengthened and re-enforced at healthcare facilities. One of the most striking features in this study was the low proportion of HCWs for whom HIV status was known. HCWs must be encouraged to test for HIV and to disclose their status to the occupational health nurse so that they can commence antiretroviral therapy timeously.

Ideally, healthcare worker TB notification systems should be established in both public and private sectors to accurately measure and monitor the burden of TB among HCWs in South Africa.

LESSONS LEARNED
1. Records from occupational health clinics are likely to underestimate the incidence of TB among HCWs. A more rigorous surveillance system for TB in HCWs is required.
2. HCWs are unlikely to report their HIV status to their occupational health services. Occupational health nurses and doctors should encourage disclosure of HIV, especially among HCWs diagnosed with TB.

“Many HCWs use private healthcare providers in this largely urban district, which could result in underestimates . . . ”

“Ideally, healthcare worker TB notification systems should be established in both public and private sectors to accurately measure and monitor the burden of TB among HCWs in South Africa.”

DECLARATION OF INTEREST
The authors declare that they have no conflicts of interest or affiliations to any commercial organisations.

REFERENCES