Summary
A modelled strengthened CHW platform to support CHW-led TB case detection and adherence support translates in South-Africa to a high net benefit to cost ratio of 4.8.The largest contributor to the benefits stems from the value of the DALYs that have been averted through reduced deaths and reduced morbidity due to increased case-finding and cure rate. This analysis adopts a provider perspective and does not consider the broader savings to potential patients through averted infections. A crucial element in the success of CHW supported services is the standardization and adequacy of renumeration, as well as the strengthening of training and crucially supervision/support to ensure a high quality of service provision.

The problem
The deployment of CHWs has been demonstrated to be an important and cost-effective strategy in a range of low-and-middle income and underserved contexts where chronic shortages of nurses and doctors and large distances to health facilities have resulted in limited access to essential health services for vulnerable populations.(Vaughan et al., 2015) South Africa has a long history of using CHWs, spanning close to 5 decades. At present, CHWs are polyvalent paid workers and their roles have expanded to support the delivery of a range of high priority interventions. While CHWs have played an important role in amplifying the success of many of these programmes over the years, there has been significant inconsistency in the resourcing, management and functioning of the programme across South Africa(Schneider H, 2018). The absence of a developed CHW policy has meant that there has been no guidance on their qualification requirements, training, employment conditions, or scope of practice (Doherty et al., 2016). In addition, the lack of proper resourcing, estimated to comprise under 5% of PHC level expenditure in South Africa (Besada D, 2019), has led to inadequate coverage of CHWs, uneven training, limited provision of equipment and very importantly a poorly staffed supervision structure to support their work. The lack of detail on the CHW scope of practice has somewhat been addressed in the South African Department of Health's formalized Policy Framework and Strategy for WBOTs introduced in 2018, however financial commitments to resource this programme remain elusive. In order to advocate for increased resourcing of the CHW platform, the question arises*, what would the impact of an adequately resourced CHW platform? And would these additional benefits outweigh the input costs required?* This brief presents part of the analysis for TB.

South Africa ranks among the top 10 high TB burden countries. With 567 new cases per 100 000 population, South Africa has the second highest rate of TB incidence after Lesotho; collectively these two countries account for 31% of the world's burden of TB, and 37% of TB deaths.(Padayatchi et al., 2019). Furthermore, while multidrug-resistant tuberculosis (MDR-TB) prevalence rates have remained stable, at 2.9%, in the 2001–2002 South African survey, compared with 2.8% in 2012–2014, the rate of rifampicin resistance (RIF-R) has increased, from 3.4% to 4.6% (Diseases., 2016). The TB epidemic in South Africa is primarily driven by its concurrent HIV epidemic. SA reported the highest number of HIV-associated TB cases worldwide in 2017, with 60% of incident TB cases coinfected with HIV and HIV-positive TB mortality accounting for 71.8% of deaths among patients with TB. (WHO, 2018). While traditional cohort analysis reports a 75% treatment success rate, a detailed cascade of care analysis on 2013 programmatic data (Naidoo et al., 2017) found that just 53% of the estimated TB cases resulted in successful treatment completion. The study revealed a series of stepwise losses along the treatment pathway, from care seeking to treatment completion

The analysed solution
While estimated tuberculosis incidence rates and mortality appear to be decreasing in South Africa as a result of the expansion of the large roll-out of ARV treatment, the current rate of decline is too slow to meet the 2030 Sustainable Development Goals or 2035 End TB Strategy targets (Strategy, 2015)]. Pren Naidoo et al.(Naidoo et al., 2017) have indicated that by 2030 and 2035, tuberculosis incidence rates for South Africa would need to decrease to 167 and 83 cases per 100 000 population, respectively, and mortality would need to decrease to 9800 and 4900 cases, in order to reach global and local TB targets. Achieving these ambitious targets therefore requires a more invigorated response, shifting away from the historical focus on treatment success rates, which fails to reflect upstream losses contributed by individuals who do not access health services and by those for whom tuberculosis is not diagnosed, notified, and treated.

Global evidence has revealed that a well-resourced and supported CHW platform has the potential to increase both case finding and treatment success rate by supporting person-centered care, including raising TB awareness (and) providing TB information in local languages to communities,

in addition to following up on defaulters. CHWs were demonstrated to increase case detection by a range between 16% (Ospina et al., 2012) and 55%(Miller et al., 2010) while treatment success through household visits by a nurse or lay counselor led to a 55% reduction in TB transmission over 3 years and a 12% reduction in TB prevalence (Ayles et al., 2013)

The modelled intervention consists of a four-fold increase in funding for the CHW platform to secure additional CHWs, alignment of their stipend to the national minimum wage, systematic ongoing training, dedicated supervision, 1 laptop per team to improve planning of coverage, patient monitoring and data analysis by team supervisors, mobile phones for both supervisors and the CHWs and the adequate refilling of job kits and airtime. Given the polyvalent nature of CHWs, an analysis of the 2017 burden of disease and demographic structure of the population in South Africa shows that CHWs would spend approximately 8% of their time on TB-related activities; 8% of the increased funding was thus allocated to TB services in the model. The analysis considers HIV positive and HIV negative populations separately as life expectancy and case fatality rates between these two populations varies significantly. This modeled intervention drew on conservative estimates of a 10 percentage point improvement (68%-78% for TB and 73% to 83% for MDR-TB) in case detection and a 5 percentage point improvement in treatment success for both TB(82%-87%) and MDR-TB treatment (55%-60% for MDR) and in turn estimates the resulting deaths averted, DALYs averted, and the benefit/cost ratio of the modelled intervention. The analysis summarizes the cumulative costs and impact over 10 years of a scaled-up CHW platform on TB outcomes and the multiplier effect of additional salaries for CHWs and supervisors spent back into the local economy. A sensitivity analysis was run on the scenario estimates for case detection and treatment success by applying both a 20% reduction and 20% increase for each.

The costs and benefits

Additional Cost (over 10 year period) of the CHW intervention for TB	**Percentage within categories of cost**	**Value**
Capital/set-up costs (4% of total cost of platform)	100%	$12,689,639
Training	31%	$3,922,204
Equipment	69%	$8767434
Recurrent (96% of total cost of platform)	100%	$288,083,673
Overheads	9%	$26189425
Equipment	10%	$28272557
CHW & supervisor salaries	81%	$233,621,690
Additional cost of additional treatments due to intervention		**Cost of Treatment**
Additional TB & MDR-TB treatment		$77427289
Total Additional Cost		**$378,200,600**

*The costs are reported in 2018 dollars and have been discounted at 5%.

Benefit	Percentage within categories of benefits	Value
44,641 avoided deaths		incorporated in value of DALYS below
1,163,818 avoided disability adjusted life years Combines DALYS averted due to reduced mortality and morbidity	99.2%	$8,044,397,969
Savings due to **171,845** avoided TB & MDR treatments as a result of reduced transmission	0.5%	$40,237,945
Multiplier effect of additional salaries	0.3	$26,389,580
Total benefits		**$8,111,025,495**

Benefit to Cost Ratio (HIV + and HIV -)	**4.8 (4 – 5.2)**
Benefit to Cost Ratio (HIV+)	**6.1(5.1 – 7)**
Benefit to Cost Ratio (HIV -)	**2.8 (2-3- 4.4)**

With a benefit to cost ratio of 4.8, this CHW led intervention represents a high net benefit relative to input costs. The BCRs have also been calculated independently for HIV + and HIV – populations, although the different costs are not presented. It is important to note that the HIV+ BCR is both for those on ARVs and those not on ARVs but the analysis demonstrates that the BCR for HIV+ populations is double that of HIV- populations. The intervention does not however provide immediate savings to the health sector, since the cost of additional treatments is higher than the savings incurred through avoided treatments. The largest contributor to the benefits stems from the value of the DALYs that have been averted through reduced deaths and reduced morbidity. The benefits incurred through avoided TB treatments due to reduced transmission and incidence represents a far smaller proportion of the total benefits. However, reduced transmission provides a

broader societal benefit beyond the health sector through the DALYs averted and their impact on the economy due to the improved health status of the population. The analysis does not account for a reduction in the time to diagnosis through increased case-finding, and therefore could be an underestimate of transmissions averted. This analysis, however, adopts a provider perspective (ie cost to the health system) and does not consider the broader savings to potential patients directly stemming from reduced infections and successful treatments. While treatment for TB is provided free of charge, there still remains a cost burden on patients related to transport to facilities and a loss of income both to themselves and their care-takers.

Discussion

The PHC re-engineering strategy currently being implemented in South Africa envisions that CHW programmes will be transformed away from being employed and trained in vertical programmes into a system where they have a common role, serve more than one programme and have a core set of competences.(Heunis et al., 2013) While this analysis and policy brief focused on the TB related services, the comorbid nature of conditions, with the growing quadruple burden of disease in South Africa has necessitated an integrated response to service delivery. The broader investment case conducted by the South African Medical Research Council demonstrated that the strengthening of the CHW platform was also highly cost-effective for CHW supported interventions for Maternal and Child Health, HIV, and diabetes. Furthermore, palliative care provided by CHWs in the home translates into significant savings to the health sector.

However, scaling-up CHW programmes runs a high risk of overburdening CHWs and neglecting the necessary quality criteria, (Hermann et al., 2009) with the insufficient training of existing cadres as further reason for concern (Languza N, 2012). As noted earlier, a crucial element in the success of CHW supported services is the standardization and adequacy of renumeration, as well as the strengthening of training and supervision support to ensure a high quality of service provision. CHWs that are effectively supervised are motivated and perform a greater range of tasks. (Tseng et al., 2019). Furthermore, the acceptability of CHWs within communities is key to ensure higher case finding and adherence support.

This analysis has demonstrated that strengthening the CHW platform has the potential to significantly improve TB and MDR-TB outcomes. Given the highly contagious nature of un-managed TB, increasing case detection and resulting treatment coverage, in addition to improving treatment success through CHW led adherence support and defaulter tracing, results in both transmissions and deaths averted, as well as a reduction in TB incidence. The monetarized value of benefits far outweighs the investment. This approach would be relevant for any resource constrained setting with inadequate human resource coverage to address their infectious disease epidemics and the growing burden of non-communicable diseases. This analysis demonstrates that this intervention would result in significant gains in settings with high TB incidence, inadequate case finding and poor access to PHC facilities, both with and without a concurrent HIV epidemic.

The 2018 WHO TB report highlight 14 countries in the world with a high burden of each of the 3 diseases. Of the 14, 8 were in Sub-Sahara Africa: Angola, DR Congo, Ethiopia, Kenya, Mozambique, Nigeria, South-Africa and Zimbabwe. With many countries reporting far lower coverage and success rates than South Africa, the magnitude of improvement of the suggested intervention is likely to be much higher. This analysis is also of relevance for countries which are still in the process of exploring a formalized CHW platform. In South-Africa the additional cost of strengthening the CHW platform may be higher than in other settings, particularly in Sub-Saharan Africa, on account of higher CHW stipends and salaries of supervisors. Despite this, the value of the additional benefits far outweighed the costs.

Further implementation research to assess the effect of different supervision interventions on CHWs' perceptions of support and resulting motivation and heath related outcomes could be explored in settings with limited nurse personnel available to provide that role. In addition, effective community health information systems are critical in settings that are increasingly relying on CHWs to ensure that the health information generated by them is linked to the facilities for the continuity of patient care. Yet, in most countries, this vital information on health services provided by CHWs is not routinely captured and there is a need to increasingly explore the role of mHealth technologies to improve data capturing and monitoring.

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