Saving lives, saving costs

Investment Case for Community Health Workers In South Africa

What costs and what benefits
For the health sector, for the economy and
For society?

Updated for R3,500 stipend

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DISCLAIMER

This SAMRC working paper is a report presenting results of the costs and benefits of CHW platform through modelling the results of a literature review to the South-African situation. It is being disseminated to stimulate discussion and to contribute to public debates about CHWs platform. The analysis and conclusions are those of the authors.

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EXECUTIVE SUMMARY

Community health workers (CHWs) are increasingly shown to have the potential to improve the health status of the population, in particular that of the more disadvantaged or those living in hard to reach areas. Their involvement in mother and child programmes, HIV/AIDs and TB programmes as well as chronic diseases and palliative care has been documented across many countries. Many studies have documented impressive impacts due to better prevention through health education, to significantly higher case-finding than in standard care, better support for treatment adherence and increased control or cure rate, to better support for palliative care allowing patients to remain with their families at the end of their lives. However, in many low income countries the CHW platform has been very patchy with inadequate training, inadequate support and supervision, uncertain funding and low morale amongst CHWs. This weak system then leads to underperformance and disappointing results.

In South Africa in 2012 the government launched the PHC re-engineering approach which placed the WBOTs system (Ward-based outreach teams) firmly in the continuum of PHC services with strong linkages with PHC facilities and district hospitals to improve access, detection and support in the community. The roll-out of WBOTs has been uneven and this platform is generally under-resourced. A new study on WBOTs in 2 provinces, with more developed WBOTs system, showed that expenditure on WBOTs represented under 4% of their respective PHC expenditures.

The purpose of this investment case commissioned by the National Department of Health is to assess the return on investment of a strong CHW platform in South Africa. This version 3 updates the version 2 by modelling the impact of a CHW monthly stipend increased to R3,500 on cost and cost-effectiveness of the platform.

This report reflects the potential of a high performing CHW platform based on findings from South African or international literature. The first part focusses on the impact of CHWs on the health sector. It follows a life course model and focusses on mother and child health, HIV/AIDs, TB, Hypertension, Diabetes and Palliative care. It estimates deaths averted, DALYs averted, cost per additional DALY averted and whether the intervention is cost-effective or even cost-saving.

The second part of the report focusses on the benefits for the economy and society of the stronger CHW platform. It first looks at the multiplier effect of the CHW platform on increased employment, and at the impact on the economy of employing mainly poor women. It then estimates the productivity impact of improved health status of the population through CHWs interventions.

Finally the report presents the costing of an adequately resourced and supported CHW platform. It first presents absolute yearly costs, then the additional costs of this platform since some aspects of this platform already exist and are paid for.

Methodology

We compare a standard situation without CHWs to a scenario with a well performing CHW platform with suggested staffing norms for CHWs. We present year 1 as the first year of the fully functional CHW platform where improved case finding and adherence or cure rates apply. The time horizon is 10 years during which

these improved rates apply. The rates are extracted from the literature and we have used a conservative approach in the choice of rates. Cost effectiveness is assessed using the WHO thresholds whereby an intervention is considered cost-effective if the cost per DALY averted is equal or inferior to three times the GDP per capita, and highly cost-effective if the cost per DALY averted is equal or inferior to the GDP per capita. Interventions are classified as cost-saving if the cost per DALY averted is negative.

The number of home visits per type of condition required for the non-insured population of South-Africa is calculated based on the demographic structure of the population and the burden of disease. Time available for home visits is calculated after quantifying time on other activities. New staffing norms (number of households per CHW per year), based on 6 hours a day 5 days a week, are suggested for urban areas, then weighted for rural and deep-rural areas. The resulting number of CHWs and team leaders required form the base of the costing of the platform. The costing of the platform reflects total costs, and includes annualised cost of training and equipment as well as stipends for CHWs, salaries of team leaders and overheads. This platform is currently partially paid for, additional costs are also presented. The share of time CHWs spend per condition (MCHW, AIDS, TB…) is calculated from the distribution of home visits as explained above.

In the section on benefits for the economy and society, two methods, one of them from the IMF, are used to estimate the multiplier effect of additional employment compared to the current situation, both arriving at the same value. Calculations are adapted to the South African context: middle income economy with low growth rate and where an added injection of funds will be spent by mainly poor women with the implication that this injection will be spent in the economy and not saved. The added benefits of that injection mainly aimed at women and hence more likely to benefit the health status and education of children, are also presented. Additions to the GDP by people whose death was averted is calculated by applying the GDP per capita to each life year saved.

All prices are expressed in 2017 Rands. Throughout the study a discount rate of 3% is used for DALYs and for costs.

Results

Benefits for the health sector

Mother and child:

It is assumed, conservatively, that a well-functioning CHW platform would Increase the coverage of a selection of interventions by 10%. This would translate into 34,800 additional lives saved over 10 years and over 1 million DALYs would be averted. Improvements to feeding practices would have the biggest impact. The case detection and referral that CHWs could provide for pneumonia and diarrhoea would save more than 900 lives and account for 28% of the deaths prevented. Preventive care (support for improved hygiene and sanitation practices) accounts for 14% of lives saved. Promotion of vaccines accounts for 11% of the lives saved and promotion of quality antenatal care for an additional 9%. If CHWs spend 19% of their time on MCH, the cost per DALY averted would stand at R18,103, a highly cost-effective intervention when the GDP per capita stands at R78,254.

HIV/AIDS:

Over 10 years the cumulative number of deaths averted through CHWs' interventions stood at 96,923. Cumulatively 343,743 new infections were avoided. The number of resistant cases avoided, through better case finding and higher adherence, amounted to 503,807 over 10 years. Over 10 years, 1 million DALYs were averted. The cumulative savings of 50% of patients being managed in adherence clubs compared to standard management would be R18.3 billion. The resistant cases averted would translate into a saving of R20.5 billion. The cumulative cost of CHWs spending 27% of their time on HIV/AIDS and the existing facility-based lay counsellors spending 80% of their time on HIV/AIDS would stand at R15 billion over 10 years. Combining savings and additional costs, the CHW and Lay counsellors intervention for HIV/AIDs would translate into a cumulative saving of R21 billion over 10 years. The cost per DALY averted would amount to R-19,999. This negative number shows a saving per DALY averted. The intervention of CHWs through higher case-finding, higher retention, lower transmission, lower resistance and cheaper treatment management than standard care leads to the intervention being not only highly cost-effective but also cost-saving.

TB:

Increasing the case finding rate and TB cure rate by a conservative 10% each would translate into 33,064 multiple drug resistant (MDR) cases averted, 16.4% fewer deaths in the scenario with CHWs compared to standard care, or 60,642 additional deaths averted over 10 years, and over 1 million DALYs averted. DOTs system with CHWs are cost saving compared to clinic-based DOTs. Combining first treatment savings, with the savings due to averted MDRs, with the cost of the CHW platform if CHWs spend 8% of their time on TB, would translate into annual saving of 10% on the TB budget. The cost per DALY averted would stand at R-2,121, a negative value indicating costs saving. The TB intervention is not only highly cost-effective by WHO criteria, it is also cost-saving.

Chronic Diseases

Hypertension:

Hypertension is a major risk factor for the development of cardiovascular disease, which is the leading cause of NCD-related mortality. It is associated with numerous co-morbidities. Increasing case-finding/treatment coverage by 10% and performing two annual home visits for uncontrolled patients would avert 14,266 DALYs over 10 years. In addition, the annual decreased risk of death amongst hypertensives on treatment would translate into 6,588 fewer deaths. If CHWs spend 10% of their time on hypertensives, the cost per DALY averted would amount to R105,051. At a cost higher the GDP per capita (R78,254) but lower than 3 times the GDP per capita, this intervention is cost-effective by WHO thresholds.

Diabetes

We assumed conservatively, based on the literature review, that the diagnosis rate will increase by 7% due to systematic screening by CHWs and that the rate of controlled diabetes increases by 7%. Controlled diabetes is associated with a reduced risk of hospitalisation and adds 6.9 years to life expectancy compared to uncontrolled diabetes. Over 10 years 1,195,112 DALYs would be averted with the increased number of controlled patients in the CHW scenario. R5.7 billion will be saved in hospitalisations averted. With CHWs spending 10% of their time on diabetics, the cost per DALY averted would amount to R6,096. CHWs intervention for diabetes is a highly cost-effective intervention.

Palliative Care

This section estimates the savings for the health system of home-based care for palliative patients as opposed to hospital stay for those patients who can be managed at home. Currently 1 out of 6 beds in the Cape Metropole are occupied by patients requiring palliative care and 50% of patients requiring palliative care are hospitalized with an average stay of 2 weeks. If 50% of those hospitalized were managed at community level and extrapolating to the population of the country, 88,290 hospitalisations would be avoided a year. For the same 2 weeks, palliative care at home would require 1 outreach visit by a doctor, an average of 6 visits by a PN and 8 visits by a CHW. The yearly cost of home management, including doctors, PNs and CHWs' visits, would be R331 millions, whilst it would have been R3.7 billion if managed in hospital. About R3.3 billion a year would be saved, or R29.3 billion over 10 years.

Benefits for economy and society

Multiplier effect of new cash injection in the economy

Based on several sources, including IMF and World Bank, and based on the economic and social situation in South Africa, a multiplier level of 1.5 was calculated for the CHW injection. This value represents the cumulative impact on GDP achieved over a series of years. For the purposes of modelling, we assume that the full impact is felt in the third year, with the impact at 1.2 in the first year, 1.4 in the second year, and 1.5 in the third year.

With the approximately R2 billion already spent yearly on the CHW platform, an estimated 1.4 billion on salaries/stipend, the additional injection for salary would amount to R5.4 billion a year. The effect of the multiplier for additional salaries injection will add to the economy R12 billion in year 1, an additional R1 billion in year 2, and an additional R544 million in year 3; thereafter the impact of the multiplier ceases. Cumulatively an additional R13.6 billion would be added to the GDP.

There is much evidence of the "significant" macroeconomic gains that result when women can realise their full potential in the labour market as well as being the most important poverty-reducing factor in developing countries. There is also widespread recognition that giving money to poor women is more likely to result in benefit for other members of the household, and particularly children, than giving money to poor men.

Productivity impact of improved health status

By averting deaths, CHWs contribute to make available an additional workforce. Each year of life saved during the productive years adds the yearly value of GDP per capita to the country GDP, based on WHO methodology. The deaths averted during 10 years of the CHW platform would contribute cumulatively an additional R413 billion to the GDP.

Staffing norms and Costing of the platform

The number of home visits would amount to an average of 1.7 home visits per capita per year. CHWs will spend the equivalent of 3.7 days a week on home visits, the other 1.3 days equivalent being spent on other activities (visiting ECD institutions, health days, clinic….). A CHW could do an average of 22 home visits a week in urban areas, 17 in rural areas and 14 in deep-rural areas. With 1.7 home visits per capita per year and an average of

3.8 people per household, the number of households a CHW could cover is thus 150 in urban areas, 112 in rural areas and 92 in deep-rural areas. 96,030 CHWs would be required to cover the non-insured population of South-Africa and with an average of 10 CHWs per team, 9,603 dedicated team leaders.

It is estimated that R2 billion is currently being spent on the CHW platform with an average of 60,000 CHWs paid directly or indirectly by the government.

The CHW stipend in this version was modelled to R3,500 a month.

The yearly total financial costs to train, equip, support/supervise, and pay the stipend of CHWs and salaries of team leaders and district CBS manager as well as general overheads, would stand at R8.8 billion. Given the R2 billion already in the system, this amounts to an additional injection of R6.8 billion a year. The total cost of the platform would represent 17.7% of the current public sector PHC expenditure.

If WBOTs were deployed only amongst populations of wealth quintiles 1 and 2 (the poorest of the 5 quintiles), the total cost would amount to R3.5 billion, an addition of R1.5 billion to the current CHWs' budget. However limiting to quintiles 1 and 2 would be difficult to operate as the limitation would have to be made on a geographical basis and risk excluding needy households.

Discussion

Community health platforms are in many countries patchy, under resourced and with unsecured budgets. As a consequence their impact has been suboptimal. However numerous studies have shown the potential of highly performing CHWs interventions, showing significant numbers of deaths averted, DALYs averted and financial savings for the health system.

To ensure adequate and on-going resourcing of the CHW platform, the government must satisfy itself that such investment is justified by the returns it brings. Return on investment is the focus of this investment case.

Despite a conservative approach and scope, all interventions by CHWs in the fields of mother and child health, HIV/AIDs, TB, Hypertension and Diabetes would lead to a decrease of just under 200,000 deaths over 10 years and to 4.8 million DALYs averted. All these interventions have been shown in this study to be highly cost-effective (MCHW, AIDS, TB, Diabetes) or cost effective (Hypertension), as per the WHO thresholds. In the areas of HIV/AIDs, TB and palliative care, CHWs interventions are in fact cost-saving for the health-system. Combining all interventions and the cost of the platform a saving of R30 billion could be made over 10 years.

The economy and society at large would also benefit from a strengthened platform. The injection of the added salaries spent in the economy, would translate into an amount of R13.6 billion added to the country GDP over the first 3 years. In addition, the better health status of the population and the deaths averted through the CHWs interventions, translate into an additional 5 million productive life years added to the workforce over 10 years, or R413 billion added to the GDP.

Some interventions have been shown to be cost saving or incur a low cost per health impact whilst others, although cost-effective, have a higher cost per health impact. Focusing on cost saving interventions only would be in contradiction with the goal of an integrated platform and would not be desirable due to the large component of co-morbidities, nor feasible. Reducing the number of interventions in order to increase the

population covered by each CHW and thus reducing the number of CHWs would make walking to the more distant homes impossible.

In order to enable the benefits from the CHW platform, additional funding must be made available to build and maintain this platform. It is already partly funded by the government to the tune of approximately R2 billion a year. With the new suggested staffing norms and with a monthly stipend level of R3,500, an adequately trained, equipped and supported platform would require an additional R6.2 billion a year.

A highly performing CHW platform would improve health status and create savings for the country.

BACKGROUND

Community health workers (CHWs) are increasingly shown to have the potential to improve the health status of the population, in particular that of the more disadvantaged or those living in hard to reach areas. Their involvement in mother and child programmes, HIV/AIDs and TB programmes as well as chronic diseases and palliative care has been documented across many countries. Many studies have documented impressive impacts due to better prevention through health education, to significantly higher case-finding than in standard care, better support for treatment adherence and increased control or cure rate, to better support for palliative care allowing patients to remain with their families at the end of their lives. These studies have often taken place in adequately resourced situations and have shown that CHW-based interventions can be very cost-effective. However the maintenance of these benefits has been patchy. Some studies have shown disappointing results pointing to inadequate training, inadequate support and supervision, uncertain funding and low morale amongst CHWs. Many countries suffer from an uneven community-based care system (CBS) which is under-resourced, leading to serious underperformance.

In South Africa, in 2012 the government launched the PHC re-engineering approach which placed the WBOTs system (Ward-based outreach teams) firmly in the continuum of PHC services with strong linkages with PHC facilities and district hospitals to improve access, detection and support in the community. The roll-out of WBOTs has been uneven and this platform is generally under-resourced. A new study (http://www.mrc.ac.za/healthsystems/publications.htm) on WBOTs in 2 districts in 2 provinces, with districts chosen because of the more advanced state of the WBOTs system, showed that expenditure on WBOTs in both districts amounted to under 4% of their respective PHC expenditure. The number of home visits per capita was under half what would be expected given the respective demographic structure of the population and burden of disease. This under resourcing inevitably stifles the potential impact of CHWs services. Despite recommendations from the NDoH for a conservative R2,500 stipend, there is currently no standardisation of stipends for CHWs, with stipends ranging from R1,700 a month for a 40 hours week in the Kwazulu Natal province, to R2,500 a month for 30 hours a week in Gauteng province, to R3,500 a month for 18 hours a week in the Nelson Mandela Metro in the Eastern Cape province, compounded by insecurity of employment. This situation weighs heavily on the impact of CHWs.

The NDoH requested that an investment case for CHWs be carried out to reflect the return on investment of a well-functioning WBOTs platform, with specific reference to:

- The potential benefits from this platform
- The cost of an adequately resourced CHW platform

This report is an update on Version 2 (April 2018) of the investment case. Version 2 integrated the recommendations of a new policy for CHWs which was adopted in December 2017, increasing the scope of practice of CHWs and opting for a single cadre, combining CHWs and Home-based carers who existed in the previous policy. With the new policy came the need to reassess the existing staffing norms translating into increasing number of CHWs required, necessitating an update of the costing. This report (Version 3 May 2018) models the impact of an increased CHW monthly stipend at R3,500 a month.

The first part of the report focusses on the benefits of a well performing CHW platform for the health sector. It uses a life course model and focuses on mother and child health, HIV/AIDs, TB, Hypertension, Diabetes and Palliative care. It estimates deaths averted, DALYs averted, cost per additional DALY averted and whether the intervention is cost-effective or even cost-saving.

The second part of the report focusses on the benefits for the economy and society of the stronger CHW platform. It first looks at the multiplier effect of increased employment on the CHW platform, and at the impact on the economy of employing mainly poor women. It then estimates the productivity impact of improved health status of the population through CHWs interventions

The third part of the report covers the modelling of the activities and number of home visits required for the South-African uninsured population, given the new scope of work of CHWs. New staffing norms are calculated.

The fourth part presents the costing of an adequately resourced and supported CHW platform resulting from the new staffing norms and the new modelled stipend. It first presents absolute yearly costs, then the additional costs of this platform since some aspects of this platform already exist and are paid for.

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For the purpose of this research we compared a standard situation without CHWs to a scenario with well performing CHW platform. We present year 1 as the first year of the fully functional CHW platform where improved case finding and cure rates apply. We then assume a maintenance over 10 years of these improved rates.

For ease of checking references, and due to the long reference list, we have placed the references at the end of each section.

BENEFITS FOR THE HEALTH SECTOR

Mother and Child Health

Community Health Workers (CHWs) have provided health care to South African communities for decades, assuming a variety of roles and performing a number of tasks focused on health promotion and disease prevention. CHWs are particularly important in rural and remote populations with limited access to healthcare. They can play a crucial role in throughout pregnancy, the postnatal period and early childhood, saving the lives and improving the health of young children and their families.

Mortality of children under the age of five years is one of the most important public health challenges in South Africa. Every year, an estimated 40,000 children die before their fifth birthday. The under-five mortality rate (U5MR) has declined in the last decade but it remains unacceptably high at 42 deaths per 1,000 live births, according to the 2016 South Africa Demographic & Health Survey. As progress has been made reducing deaths from HIV/AIDS and other infectious causes, half of all child deaths now take place in the neonatal period, or the first month of life. The leading causes of death for children under-five include pneumonia (17%), complications of prematurity (12%), injuries (9%), diarrhoea (9%), and HIV/AIDS (9%).

Table 1. Estimated proportionate causes of death in SA for neonates, infants and children, 2015

Cause of death	**0-27 days**	**1-59 months**	**0-4 years**
HIV/AIDS	0.8	11.5	8.7
Diarrhoeal diseases	0	11.8	8.7
Pertussis	0	0.6	0.4
Tetanus	0	0	0
Measles	0	1.7	1.2
Meningitis/encephalitis	0.1	1.7	1.3
Malaria	0	0.1	0.1
Acute lower respiratory infections	6	20.9	16.9
Prematurity	35	3.9	12.2
Birth asphyxia and birth trauma	21.4	1.9	7.1
Sepsis and other infectious conditions of the newborn	14.5	0	3.8
Other communicable, perinatal and nutritional conditions	11	14.7	13.8
Congenital anomalies	9.2	8.3	8.6
Other non-communicable diseases	0.4	11.1	8.3
Injuries	1.5	11.6	9

(source: WHO for the year 2015, cause of death input to the LiST model)

The potential impact of interventions supported by Community Health Workers

In South Africa, several studies have shown the importance of community health workers to child health. To show the impact that CHW interventions can have on reducing child mortality, a model based analysis was conducted using the Lives Saved Tool (LiST). LiST was used to estimate the health impact of scaling up interventions that could potentially be delivered directly by CHWs at community level, or promoted by CHWs in homes and communities and delivered at the health centre or hospital. Interventions throughout pregnancy, the postnatal period, and early childhood that have been shown to reduce mortality were used in the model (Box 1).

Box 1. Interventions scaled up in LiST by 10 percentage points*^

- ANC 4+ (including syphilis, hypertension, diabetes, pre-eclampsia detection and case management)
- Micronutrient supplementation in pregnancy
- Exclusive breastfeeding (0-6 months)
- Extended breastfeeding (6-23 months)
- Complementary feeding
- Clean postnatal practices
- Improved sanitation
- Handwashing with soap
- Vaccines: pentavalent, pneumococcal, rotavirus, measles
- ORS for diarrhoea (used data on ORS for this input, not RHF)
- Zinc for diarrhoea
- Antibiotics for pneumonia (used data on care-seeking as a proxy)

*Coverage of skilled birth attendance and health facility delivery were already over 95% according to SADHS 2016 so these interventions and their components were left unchanged, but presumably good CHW support could help families advocate for better care during delivery and coverage of quality newborn care could increase.

^ Interventions were scaled up by 10 percentage points from 2017 values in the first year of the CHW program (i.e. 2018), and extrapolated at that coverage level through 2027. Additional inputs to the CHW platform that may facilitate a further increase in coverage would result in more deaths averted.

The modelled LiST results showed that with an increase in coverage of key interventions by only 10 percentage points, an average of 3,500 under-five deaths would be prevented each year. Cumulatively between 2017 and 2027, over 34,800 lives would be saved.

Improvements to feeding practices including early, exclusive and extended breastfeeding as well as complementary feeding would have the biggest impact (Table 2). The case detection and referral that CHWs could provide for pneumonia and diarrhoea would save more than 900 lives and account for 28% of the deaths prevented. Preventive care, mainly support for improved hygiene and sanitation practices accounts for 14% of lives saved. Promotion of vaccines accounts for 11% of the lives saved and promotion of quality antenatal care accounts for an additional 9%.

Table 2. Additional deaths prevented with a 10 percentage point increase from 2016 coverage levels

Intervention	Number of deaths prevented in the first year of CHW scale up	% deaths prevented
Pregnancy		
Micronutrient supplementation, syphilis detection and treatment	294	9%
Breastfeeding		
Early, exclusive and extended breastfeeding, complementary feeding)	1270	38%
Preventive		
Improved hygiene (Clean postnatal practices, handwashing with soap, improved sanitation)	453	14%
Vaccines		
Pentavalent, pneumococcal, rotavirus, measles	357	11%
Curative		
Case management of pneumonia	537	16%
ORS and zinc for diarrhoea	407	12%
Total	*3,314*	*100%*

With a life expectancy of 64 years and a discount rate of 3%, each death averted would translate into 28.6 DALYs averted. For the annual 3,314 deaths averted, the number of DALYs averted would stand at 94,741. Cumulatively over 10 years just under 1 million DALYs would be averted.

Cost per DALY averted

If the CHWs spend 19% of their time on mother and child health (Table 15), the cost of the MCH CHW platform would amount to R1.7 billion. The cost per DALY averted would stand at R18,013. The WHO's thresholds for cost-effectiveness categorise as cost-effective an intervention whose cost per DALY averted is equal or inferior to three times the GDP per capita and as highly effective when the cost per DALY averted is equal or inferior to the GDP per capita. For a GDP cost per capita of R78,254 for this intervention the cost per DALY averted is 23% of the GDP per capita and is classified as highly cost-effective.

Share of CHW time	19%
Deaths averted:	34,800 over 10 years
DALYs averted:	1 million
Cost/DALY averted:	R18,013

HIV-AIDS

State of HIV/AIDS in South Africa

South Africa contains the world's largest HIV epidemic, with an estimated 7.02 million people living with HIV in 2016, corresponding to a 12.7% national prevalence; this proportion rises to 19.1% amongst those aged 15- 49. The burden of HIV varies across gender and age, with peak HIV prevalence for females in the 35-39 bracket, while men aged 35-39 and 40-44 experience the highest burden of HIV. Across all age groups, with the exception of those aged 60 and older, HIV prevalence is higher amongst females. Adolescent girls and young women are the most affected, with a 5.4% vs. 2.1% prevalence among their male peers, while the HIV prevalence among female 15-19 year olds is 16.8% vs. 4.4% among 20-24 year olds). With the increase in average life expectancy due to the advent of improved antiretroviral therapy (ART), HIV prevalence is rising. The average life expectancy in South Africa has risen from 58.3 years in 2011 to 62.4 years in 2015.(SANAC, 2017)

Approximately 270,000 people were newly infected in 2016, a decline from 2012 with a reported incidence of 360 000. HIV incidence, as is the case with prevalence, is considerably higher among females than among males. The number of new HIV infections among infants has also experienced a considerable decline from 70 000 in 2004 to less than 6 000 in 2015; with the reported transmission rate declining to 1.5% by 2016.

In 2016, 150 375 people died of AIDS-related causes, representing 27.9% of all deaths in the country. This represents a decline from 33% in 2011/12. These declines in AIDS mortality are largely attributed to the massive scale-up of antiretroviral therapy.

South Africa, in the latest strategic plan, has committed, by 2022 to "*reduce the number of new HIV infections to under 100 000; eliminate new HIV infections among children; reduce TB incidence by 30% (from 834/100 000 to no more than 584/100 000); reduce the incidence of T.pallidum and N gonorrhoeae by 90%; and virtually eliminate congenital syphilis by reducing incidence to 50 or fewer cases per 100 000 live births; and maintain national coverage of HPV vaccination above 90% for grade 4 girls*".(SANAC, 2017)

Antenatal Care (ANC)

According to the latest District Health Barometer(Massyn N, 2016), the early booking rate in South Africa was 61.2%. The national average for early ANC has been steadily increasing since 2006/07, with the current rate having almost doubled, reflecting an annual increase of more than 10%. The gap between the socio-economic classes (SEQs) has steadily decreased, with all SEQs experiencing an upward trend.

The 2014/15 national target for ANC client initiated on ART was 93%, with South Africa achieving 93% nationally in 2015/16. In 2015/16, there were no clear socio-economic differentials in the uptake of ANC ART.

In 2015/16, the national PCR birth testing coverage rate was 68.7%. The national intrauterine transmission rate was estimated at 1.1%, while the positivity rate for the 1st PCR test around 6 weeks was 1.5% for 2014/15.

Condom distribution

In 2015/16 839,874751 male condoms were distributed in South Africa, compared with 712 387 234 in 2014/15. This translates to 44.4 condoms per male aged 15 years and older. The country is now aiming to distribute 1 billion condoms in 2016 (Department of Health, 2016), with Conditional Grant (CG) spending on condoms having tripled over the past three years.

Male condom distribution coverage has increased across all SEQs over the last 10 years, however SEQ1 demonstrated the highest male condom coverage at 61.6 condoms per male, while SEQ3 dropped from the highest male condom distribution coverage to the lowest coverage at 38.5 condoms per male. Male condom distribution for SEQs 4 and 5 were equal at 43.1 condoms per male aged 15 years and older.

According to the latest Demographic and Health Survey 17% of men and 5% of women age 15-49 years reported having two or more sexual partners in the past 12 months. Inadequate condom use was reported during high-risk sex, reflecting 58% of women and 65% of men who had multiple partners in the past year who report that they used a condom during their last sexual intercourse.

Testing

The South African average for HIV testing coverage has been increasing steadily, from 26.1% in 2013/14 to 34.5% in 2015/16. HIV testing coverage increased in the higher socio-economic quintiles (SEQ3–SEQ 5) between 2014/15 and 2015/16 (Figure 10). Although a downward trend was observed in the two lowest SEQs, coverage was still highest in SEQ1 (38.3%) and SEQ2 (36.7%). HCT accounted for 7% of the total CG over the three years, with total CG-related HCT spending increasing by 35%.

TB and HIV

Approximately 70% of patients with TB in South Africa are co-infected with HIV. The percentage of TB patients with known HIV status increased to 94.8% in 2015; this rate has more than doubled since the 2008 rate of 43.3%. There was no variation among the socio-economic quintiles.

The rate of TB/HIV co-infected clients on ART was 84.5 in 2015. ART initiation for TB infected patients results in significant improvements in health related quality of life and survival and serves as an indication for the quality of service integration. SEQ1 demonstrated the highest rates 89.3%, while SEQs 2, 3 and 4 all had the same rate (86.5%).

Antiretroviral Therapy)

An analysis of the cost of antiretroviral therapy in South Africa highlighted that cost savings from the introduction of new regimens can be expected due to the lower drug costs of DTG/TAF-containing regimens compared with current first-line drugs. ((Venter et al., 2016)

The cost of current first-line therapy was estimated at USD110/patient/year. The study estimated an initial 20% saving (a conservative estimate provided by manufacturers for DTG/TAF cost saving over the current regimen of EFV/TDF/FTC) and a 50% saving once volumes are met (as estimated by the Clinton Health Access Initiative (CHAI), USA).

Limiting transition of patients from first- to second-line therapy is essential to due to the significant rise in second-line therapy costs of USD350.

CHW interventions and impact related to HIV

Task shifting to trained community health workers (CHWs) has been recognized as a potential strategy by the World Health Organization to overcome staff shortages. Community health workers perform a wide range of HIV-related tasks, which include patient support such as counselling and patient education, home-based care and health service support such as screening, testing referral, drug refills and palliative support.(Mwai et al., 2013)

The systematic review (Mwai et al., 2013) of CHW interventions around HIV related care reported the following findings:

Nine studies demonstrated the role that CHWs play in providing HIV and general health education, including educating communities on symptoms and treatment of opportunistic infections in South Africa and Kenya; infection control, drug administration and reaction in Kenya and Uganda. CHWs also trained HIV-positive individuals on ART readiness and on the advantages and side-effects of ART in South Africa, Zambia and Mozambique.

Salam and colleagues (Salam et al., 2014) reviewed 39 community-based interventions (CBIs) targeting HIV knowledge, attitudes and transmission, and demonstrated that CBIs increase HIV awareness and risk reduction in addition to improving knowledge, attitudes, and practice outcomes. CBIs were found to increase knowledge scores for HIV (SMD: 0.66, 95% CI: 0.25, 1.07), increase protected sexual encounters (RR: 1.19, 95% CI: 1.13, 1.25), and condom use (SMD: 0.96, 95% CI: 0.03, 1.58), while reducing the frequency of sexual intercourse (RR: 0.76, 95% CI: 0.61, 0.96).

CHWs performed a variety of behaviour change counselling, including pre- and post-test and ART disclosure and adherence counselling in Kenya, South Africa, Malawi, Uganda, Lesotho and Zambia

The first study conducted in South Africa (Wouters et al., 2009) demonstrated that the support of a CHW significantly increased a patient's likelihood of disclosure, both at baseline (0.09, $p < 0.001$) and at 6 months later (0.16, $p < 0.001$)

Community support also emerged as an important predictor of treatment success, with patients having access to a treatment buddy reporting significantly better treatment outcomes ($\beta = 0.17$, $P < 0.001$). Furthermore, treatment response was significantly higher ($\beta = 0.11$, $P < 0.01$) among patients assigned to a CHW, and participation in a support group also had a significant positive effect ($\beta = 0.13$, $P < 0.05$) on virological and immunological measures. In addition CD4 cell count was significantly higher among patients who had high levels of community support.

Community-based support initiatives continued to show a significant correlation with the one-year treatment outcomes. Patients with a treatment buddy had a greater chance ($\beta = 0.17$, $P < 0.001$) of treatment success than patients who lacked such support, while access to a CHW significantly increased a patient's chance of treatment success by 0.16 standard deviations ($P < 0.01$). Participating in a support group also had a positive effect on the treatment outcome, with patients significantly more likely ($\beta = 0.12$, $P < 0.001$) to have an undetectable viral load and a CD4 cell count above 200 cells/µL than were patients who did not participate in

a support group. By 24 months, support of a treatment buddy (β = 0.18, P < 0.001) significantly increased a patient's chance of treatment success. In addition, having a CHW (β = 0.11, P < 0.05) significantly influenced the virological and immunological outcomes, with patients with a CHW significantly more likely to be a treatment success after 24 months than were patients without such support.

A second study in South Africa (Igumbor et al., 2011) noted better disclosure among patients with CHW support compared to patients who did not receive support (58% vs. 42%; p=0.005).

Condom Distribution and Family planning:

A meta-analysis of the impact of community-based condom distribution found eight studies demonstrating increased condom use and reductions in HIV and STIs among female sex workers (FSWs) (Kerrigan et al., 2015). Other studies have demonstrated that *peer education* and *outreach* was also associated with increased consistent condom use among both male and female sex workers, a high risk group. (Feldblum et al., 2005, Geibel et al., 2012, Kegeles et al., 1996)

A meta-analysis of the promotion of female and male condoms found a reduction in HIV and STI incidence at three months. The analyses further demonstrated that interventions that promote the use of female and male condoms increase consistent use, compared to promotion of male condoms alone.(Wariki et al., 2012)

Johnson et al (2012) fitted dynamic mathematical models to age-specific HIV prevalence data from national antenatal and household surveys, and found that adult HIV incidence has declined significantly since the 2000. The models suggested that most of this decline can be attributed to increased condom usage, while some is also attributable to the impact of ART on the infectiousness of individuals with advanced HIV. The assumed increases in condom usage align with the timing of increases in the distribution of male condoms in the South African public health sector and behaviour change interventions, while scale-up of ART coverage had not yet reached its full potential.

Both models suggest that HIV incidence in 15–49 year olds declined significantly between 2000 and start 2008 by 27-31%. The percentage reduction in HIV incidence attributed to condom use was as high as 37%.

A study in Zambia (Chin-Quee et al., 2013) to measure the impact of community-based provision of injectables for birth control demonstrated high scores on measures of safety, feasibility, and acceptability. Couple-years of protection (CYP, protection from pregnancy for 1 year) was provided to 51 condom clients, 391 pill clients, and 2,206 DMPA clients. 85% of new clients chose injectable DMPA, while 13% chose pills and 2% chose condoms. Continuation rates were also high, at 63% after 1 year as compared with 47% for pill users. Incremental costs per couple-year were US$21.24 if 50% of users continue with CHW-provided DMPA

Testing

In Malawi a study to demonstrate the uptake of services by CHWs showed that 98% of patients offered pre-test counseling underwent HIV testing and 29% were found to be HIV-positive, corresponding to a 37% detection rate. CHWs trained as lay counselors in 12 of the 14 VCT sites

conducted 41% of all HIV testing done in the district during the 2-year study period. (Zachariah et al., 2006)

In Zambia (Sanjana et al., 2009) a review of counselling and testing record books demonstrated that lay counsellors provided up to 70% of counselling and testing services at health facilities. The data review revealed lower error rates for lay counsellors than for health care workers, in completing the counselling and testing registers.

Recent Medecins Sans Frontiers (MSF) evidence from Kwazulu-Natal province in South Africa, shows that reductions in the number of lay counsellors has negatively impacted the number of HIV tests performed. (Frontieres, 2016). It showed a 25% decline in testing following the first withdrawal of community counselors and a further 13% reduction following second withdrawal. This translated into a decline in the number of patients initiated on ART, declining from 842 patients in the first three months of 2015 to 504 patients in the same period in 2016.

The success of the South African testing campaign, where 18 million people have been tested for HIV since 2009, was largely thanks to the deployment of lay counselors.

There is strong evidence that community-based approaches improve uptake of HIV counseling and Testing (HCT). Menzies and colleagues (Menzies et al., 2009) conducted a retrospective cohort study of 84,323 individuals who received HCT at one of four Ugandan HCT programmes between June 2003 and September 2005: stand-alone HCT; hospital-based HCT; household-member HCT; and door-to door HCT [13]. The study reported low per client costs for all testing strategies. While hospital-based HCT most readily identified HIV-infected individuals eligible for treatment, home-based strategies more efficiently reached populations with low rates of prior testing and HIV-infected people with higher CD4 cell counts.

A meta-analysis of community-based HCT approaches from 2013 including: (a) door-to-door testing, (b) mobile testing for the general population, (c) index testing, (d) mobile testing for men who have sex with men, (e) mobile testing for people who inject drugs, (f) mobile testing for female sex workers, (g) mobile testing for adolescents, (h) self-testing, (i) workplace HCT, (j) church-based HCT, and (k) school-based HCT found that community-based HCT achieved high rates of HCT uptake, reaches people with high CD4 counts, and links people to care (Suthar et al., 2013).

Evidence further demonstrates that door-to-door testing, or systematically offering HCT to homes in a catchment area, is effective at increasing uptake of HCT, reducing high risk behaviours and decreasing stigma (Nuwaha et al., 2012). Another systematic review and meta-analysis of home-based testing (HBT) in sub-Saharan Africa concluded that home testing increases awareness of HIV status in previously undiagnosed people, with more than 75% of the studies in the review reporting 70% uptake (Sabapathy K, 2012). Among studies reviewed, HIV prevalence ranged from 2.9% to 36.5%, and new HIV diagnosis following HBT ranged from 40% to 79% of those testing positive.
In South Africa, a cluster RCT found that door-to-door HCT increased uptake of couple counselling and testing and reduced risky sexual behaviour (Doherty et al., 2013). Home-based testing also appears to be acceptable in South Africa (Naik et al., 2012).

A study to demonstrate the cost effectiveness of home based testing in South Africa (Tabana et al., 2015), found that based on an effectiveness of 37% in home based testing compared to 16%, home based testing costs US$29 compared to US$38 per person for clinic HCT. The incremental cost effectiveness per client tested using HBHCT was $19. HIV testing uptake increased by 37% (from 32% to 69%) in the home based testing group and 16% (from 31% to 47%) in the control arm (prevalence ratio 1.54, 95% confidence interval 1.32 to 1.81)

To assess the ability of HBT to link individuals to HIV care and treatment, Van Rooyen et al. (van Rooyen et al., 2013) piloted home-based HCT with point-of-care (POC) CD4 count testing and follow-up lay counsellor visits. The study found that an integrated intervention resulted in a 91% uptake of HIV testing. 30% of those tested were HIV positive, of which 36% were new diagnoses. The authors conclude that POC CD4 testing and lay counsellor follow-up achieved almost universal linkage to HIV care and ART initiation in line with South African guidelines.

The new CHW policy now includes HIV testing in the scope of work of CHWs

Improve early antenatal care bookings

Specific interventions identified in the HIV/TB investment case (Department of Health, 2016) to improve the rates of early ANC bookings include routine pregnancy screening of all adolescent girls and women as well as community-based pregnancy screening by community health care workers. Anecdotal evidence shows the effectiveness of both community-based pregnancy testing and facility-based pregnancy testing on the impact of PMTCT. According to Wabiri (Citation: Wabiri N, 2013), 46% of pregnancies in South Africa are unplanned. Many of these women are unaware that they are pregnant, and there are thus missed opportunities for PMTCT interventions.

In addition, Andersen et al (Andersen et al., 2013), Languza et al (Languza et al., 2011) make the case for community pregnancy screening and improved outcomes with respect to early antenatal care bookings. There are currently a number of pilot projects being implemented in KwaZulu-Natal indicating that community-based pregnancy testing and facility-based pregnancy testing for women are identifying a large number of unintended pregnancies and linking them to the appropriate services.

Lilian et al(Lilian et al., 2013) found that six week testing delayed antiretroviral therapy initiation beyond the time of early HIV-related infant mortality and missed one-fifth of perinatally HIV-infected infants. Earlier diagnosis and improved retention in care are essential to reduce infant mortality and accurately measure elimination of mother-to-child transmission.

Retention support

ART adherence support by CHWs, either during home visits or through mobile phone reminders, was found to be an essential strategy to improve patient adherence and retention in care.

The 2011 HPTN 052 trial (Cohen et al., 2011) demonstrated that transmission risk was lowered by 96% among virally suppressed patients. A mathematical model.(Wilson et al., 2008) to estimate the cumulative risk of HIV transmission from effectively treated HIV-infected patients, assuming 100 sexual encounters per year, demonstrated a cumulative probability of

transmission to the serodiscordant partner a year of 0.0022 (uncertainty bounds 0·0008–0·0058) for female-to-male transmission, 0.0043 (0·0016–0·0115) for male-to-female transmission, and 0.043 (0·0159–0·1097) for male-to-male transmission.

A cohort study of study of HIV-uninfected individuals at baseline found that after holding other key HIV risk factors constant, individual HIV acquisition risk declined significantly with increasing ART coverage. An HIV-uninfected individual living in a community with high ART coverage (30 to 40% of all HIV-infected individuals on ART) was 38% less likely to acquire HIV than someone living in a community where ART coverage was low (<10% of all HIV-infected individuals on ART).(Tanser et al., 2013)

In one South African study (Igumbor et al., 2011), patients with CHW adherence support were more consistent in picking up their medication, attaining a treatment pick-up rate of 95% compared to those without CHW adherence support (67%; *p*=0.021). Although treatment pick up may not necessarily result in treatment uptake, the study showed those receiving CHW support were associated with better outcomes in terms of virological suppression, suggesting that treatment pick up was a valid proxy indicator of adherence in this study. The median time in which patients with CHW support maintained a suppressed VL was 235 days vs. 199 days. The hazard ratio for having suppressed VL with a CHW was 0.64.

In Zambia (Torpey KE, 2008), a study of the effectiveness of adherence support workers (ASWs) in adherence counselling, treatment retention, while HRH shortages at health facilities demonstrated a marked shift of workload without compromising the quality of counselling. The loss to follow-up rates of new clients declined from 15% to 0% after the deployment of ASWs.

The AIDS Support Organisation (TASO) in Uganda has been working with lay providers, called "field officers" to provide ART at home since June 2004. Adherence to ART has been shown to be very high and a recent study of the mortality under ART in this programme concluded that "the overall effect of ART on mortality was similar to or better than that seen in facility-based studies."

Adherence to antiretroviral therapy in a cohort of HIV-infected people in a home-based AIDS care programme in rural Uganda (Weidle et al., 2006) measured pill count adherence (PCA), medication possession ratio (MPR) and HIV viral load of 1000 copies per mL of patients at 6 and 12 months. The study found a PCA of less than 95% for 0·7–2·6% of participants in any quarter and MPR of less than 95% for 3·3–11·1%. Viral load was below 1000 copies per mL for 98% of 913 participants in the second quarter and for 860 96% of participants in the fourth quarter. In separate multivariate models, viral load of at least 1000 copies per mL was associated with both PCA below 95% (second quarter odds ratio 10·6 [95% CI 2·45–45·7]; fourth quarter 14·5 [2·51–83·6]) and MPR less than 95% (second quarter 9·44 [3·40–26·2]; fourth quarter 10·5 [4·22–25·9]).

Facility-based ART adherence clubs were piloted in South Africa in 2007 by MSF as a way to decongest facilities through the provision of consultations and ART collections for stable patients in clubs organised by lay health workers and peer educators at the clinic. A cohort analysis comparing patient outcomes of those joining adherence clubs to those who were eligible but remained in standard care, found that over 40 months, club participation reduced the number of patients lost to care by 57% [adjusted hazard ratio (HR) 0.43, 95%CI 0.21–0.91]

and virological rebound by 67% (HR 0.33, 95%CI 0.16–0.67) (Luque-Fernandez MA, 2013). Improved outcomes in the adherence clubs were attributed to shorter waiting times, higher acceptability of services and consequently fewer missed clinic appointments. A cost-effectiveness study showed the cost per patient year was US$58 in the ART club model, *vs*. US$109 in the mainstream model of care.(Bango F, 2013). This model was taken up by the City of Cape Town and Western Cape health services in 2011, and, was used by 19% of all ART patients in care in the metropolitan area (Bemelmans M, 2014a).

A study to compare the treatment outcomes and mortality in a rural community-based ART (CBART) program with a hospital-based ART program in Western Uganda (Kipp et al., 2010) found that virological suppression (VL<400 copies/ml) in the community cohort was similar to those in the hospital-based cohort (90.1% vs 89.3%, p=0.47). Mortality was not significantly different in the cohorts (community-based cohort 11.9%, hospital-based cohort 9.0%.

A number of studies have evaluated the impact of home-based care as a means of improving retention. In a cluster randomised trial in Uganda, Jaffar et al. found home-based care to be less costly but equivalent in terms of treatment outcomes (adjusted rate ratio of 1.04 for virological failure) (Jaffar et al., 2009a). In a randomised controlled clinical trial in western Kenya, Selke et al. also found similar results, with community-based care (equivalent to what is termed home-based care in Jaffer et al.) resulting in similar clinical outcomes but a reduction by half in the number of clinic visits (Selke et al., 2010). Two additional studies from Uganda suggest that home-based care improved treatment outcomes (Kipp et al., 2012, Marseille et al., 2009)although Marseille et al use no ART at all as the baseline comparator, thereby exaggerating the effects of home-based care.

Multicentre cohort studies found a reduction in loss to follow up over standard care (adjusted hazard ratios of 0.57 and 0.63 for adults and children respectively) as a result of community-based adherence support (Fatti et al., 2012, Grimwood et al., 2012, Igumbor et al., 2011).

A Malawi study (Kim et al., 2012) found that case management and support by dedicated CHWs resulted in an increase in the proportion of HIV-infected children enrolled on ART from 39.4% to 76.7%, demonstrating that case management and support by dedicated CHWs may help create a continuum of longitudinal care in the PMTCT cascade.

A study in four South African provinces (Fatti et al., 2014) found that community-based adherence support (CBAS) to caregivers resulted in higher rates of virological suppression (65.6% (95% confidence interval [CI]: 62.7-68.4%)) compared to non- CBAS children (55.5% (95% CI: 54.1-57.0%)) at any time-point on treatment (P < 0.0001). The effect of CBAS increased with increasing duration of ART, and CBAS particularly improved virological suppression in a higher-risk subgroup (children younger than two years), OR 2.47 [95% CI: 1.59-3.84]).

Positive associations are found when CHWs were involved with supporting TB, HIV and PMTCT programming services (Uwimana et al., 2013) and in MCH interventions targeted to reach mothers in the first six months of a child's life (le Roux et al., 2013) or when a child is a newborn (Nsibande et al., 2013).

Mobile health technology has been used to communicate successfully with CHWs, improving follow-ups at home (Schuttner et al., 2014), and this approach is being used in a pilot programme

in KwaZulu-Natal to improve the referral of patients to local clinics for further care. One sub-district in the North West province explored the development of a cell phone-based and paper-based M&E system to support the work of the CHWs. After 5 months, CHWs achieved a correspondence of 90% or above between phone and paper data (Neupane et al., 2014).

In a South African study (Igumbor et al., 2011), the median time of retention in care for patients receiving CHW support was 561 days, compared to 455 days at sites without support. The hazard ratio was 0.62 implying that non-retention in care (dying and LTF) is less likely to occur at sites with CHW support.

A randomised trial from Uganda (Chang et al., 2010) reported a two-fold difference in lost to follow-up rates at 24 months between patients who were supported by CHWs and those who were not (2.2% vs. 4.1%).

A cohort study of ART naive children in South Africa (Grimwood et al., 2012) demonstrated that amongst children who were lost to follow-up (LTFU), 38.7% died. Patient retention after 3 years of ART was 91.5% (95% CI: 86.8% to 94.7%) vs. 85.6% (95% CI: 83.3% to 87.6%) amongst children with and without CHW support. Amongst children aged below 2 years, retention after 3 years was 92.2% (95% CI: 76.7% to 97.6%) vs. 74.2% (95% CI: 65.4% to 81.0. Corrected mortality after 3 years of ART was 3.7% (95% CI: 1.9% to 7.4%) vs. 8.0% (95% CI: 6.5% to 9.8%) amongst children with and without CHWs (p = 0.060). Children with CHW support had reduced probabilities of being lost and dying, adjusted hazard ratio (AHR) 0.57 (95% CI: 0.35 to 0.94) and 0.39 (95% CI: 0.15 to 1.04), respectively.

Another cohort study in Malawi (Mwai et al., 2013) showed that CHWs were associated with reduced risk of death [RR 0.22 (0.15–0.33)]. Another study to measure the impact of weekly households visits to HIV positive patients in Uganda (Mermin et al., 2008), found 17% of participants with HIV and 1% of HIV-uninfected household members died in the two and a half year period (May 2003-Dec 2005).

Modelling CHWs impact

We modelled the impact of CHWs by comparing the standard case-finding and treatment approach with an approach where CHWs take a proactive role in case finding and in support to adherence, in particular through adherence clubs. This report has been focussing on community-based care. For HIV/AIDS in addition to community-based care, lay counsellors who are facility-based play also a very important role for counselling in facilities and running adherence clubs. For our modelling we have thus added the cost of the existing 6,463 lay counsellors who are paid a higher stipend than CHWS. This stipend varies widely between provinces we used R3,800 as monthly stipend. We calculate the additional number of deaths averted through the CHW scenario and the number of additional DALYs averted. We calculate the costs of deploying a share of CHW time for HIV/AIDS, the savings made through a share of cases using adherence clubs as opposed to standard treatment and the savings made through fewer patients developing resistance with the increased cost of second line treatments. We then calculate the cost/savings per DALY averted.

The modelling uses the following assumptions drawn from the literature review:

- Time horizon: 10 years

- The prevalence of AIDs is 12.7% of the population(SANAC, 2017)
- The incidence per year amounts to 270,000 cases
- 62% of the AIDS population are on ART
- Case finding (HCT coverage) with CHWs increases by 20% compared to the standard case-finding through HCT, currently at 34.5%.
- New cases are put on ART with the test and treat approach
- Retention in care stands at 67% in the standard treatment and 89% with CHW and lay health workers support.
- Drug resistance develops in 30% of uncontrolled patients
- 68 deaths are averted per 10,000 treatment months
- The transmission risk stands at 22% and at 4% for virologically suppressed cases
- The disability weight per DALY for patients on ART is 0.08.
- CHWs spend an average of 27% of their time on HIV/AIDS (Table 15), excluding palliative care - which is covered in a separate section, and lay health workers 80% of their time
- The cost per patient year first line stands at R1,309 in standard treatment and R695 with adherence clubs
- 50% of cases use adherence clubs
- The cost of second line treatment is R5,075 per patient year
- A discount rate of 3% is applied to DALYs averted and costs

Over 10 years the cumulative number of deaths averted through CHWs interventions stood at 96,923. Cumulatively 343,743 new infections were avoided. The number of resistant cases avoided, through better case finding and higher adherence, amounted to 503,807 over 10 years. Over 10 years, 1 million DALYs would be averted.

The cumulative savings of 50% of patients being managed in adherence clubs compared to standard management would be R18.3 billion. The resistant cases averted translated into a saving of R20.5 billion. The cumulative cost of CHWs spending 27% of their time and lay counsellors 80% of their time on HIV/AIDS would stand at R17.6 billion. Combining savings and additional costs, the CHW and lay counsellors intervention for HIV/AIDs would translate into a cumulative saving of R21 billion. The cost per DALY averted would amount to R-19,999. This negative number shows a saving per DALY averted.

The intervention of CHWs and lay counsellors through higher case-finding, higher retention, lower transmission, lower resistance and cheaper treatment management than standard care leads to the intervention being not only highly cost-effective but also cost-saving.

Table 3. Impact of CHWs and Lay Counsellors for HIV/AIDS

	Over 10 years
Additional patients on treatment with CHW interventions	17,660,173
# resistance cases avoided	(4,034,281)
Savings from resistance cases avoided	-R 20,473,974,762
Savings from CHW adherence clubs	-R 18,352,152,357
Cost CHWs	R 15,833,406,048
Cost Lay Health Workers	R 1,760,066,843
Combined costs and savings with CHWs interventions	-R 21,232,654,228
Additional deaths averted	96,923
DALYs averted due to deaths averted	780,455
DALYs averted due to infections averted	281,214
Total DALYs averted	1,061,669
Cost per DALY averted	-R 19,999

Share of CHW time	27%
Share of Lay counsellors	80%
Deaths averted:	96,923 over 10 years
DALYS averted:	1,061,669
Saving per DALY averted	R19,999

References

ANDERSEN, K., SINGH, A., SHRESTHA, M. K., SHAH, M., PEARSON, E. & HESSINI, L. 2013. Early pregnancy detection by female community health volunteers in Nepal facilitated referral for appropriate reproductive health services. *Glob Health Sci Pract,* 1**,** 372-81.

BADRI M, M. G., MANDALIA S, BEKKER L-G, PENROD JR, PLATT RW, WOOD R, BECK EJ 2006. Cost-Effectiveness of Highly Active Antiretroviral Therapy in South Africa. . *PLoS Med,* 3**,** e4.

BAEK, C., VUYISWA MATHAMBO, SIBONGILE MKHIZE, IRWIN FRIEDMAN, LOUIS APICELLA, AND NAOMI RUTENBERG 2007. Key findings from an evaluation of the mothers2mothers program in KwaZulu-Natal, South Africa. Horizons Final Report. Washington DC: Population Council.

BANGO F, W. L., VAN CUTSEM G & CLEARY S Cost-effectiveness of ART adherence clubs for long-term management of clinically stable ART patients. International Conference on AIDS and STIs in Africa (ICASA 2013), 2013 Cape Town, South Africa.

BEMELMANS M, B. S., GOEMAERE E, WILKINSON L, VANDENDYCK M, VAN CUTSEM G, SILVA C, PERRY S, SZUMILIN E, GERSTENHABER R, KALENGA L, BIOT M, FORD N. 2014a. Community

supported models of care for people on HIV treatment in sub-Saharan Africa. *Tropical Medicine & International Health,* 19**,** 968-977.

CHANG, L. W., KAGAAYI, J., NAKIGOZI, G., SSEMPIJJA, V., PACKER, A. H., SERWADDA, D., QUINN, T. C., GRAY, R. H., BOLLINGER, R. C. & REYNOLDS, S. J. 2010. Effect of Peer Health Workers on AIDS Care in Rakai, Uganda: A Cluster-Randomized Trial. *PLoS ONE,* 5**,** e10923.

CHIN-QUEE, D., BRATT, J., MALKIN, M., NDUNA, M. M., OTTERNESS, C., JUMBE, L. & MBEWE, R. K. 2013. Building on safety, feasibility, and acceptability: the impact and cost of community health worker provision of injectable contraception. *Glob Health Sci Pract,* 1**,** 316-27.

CITATION: WABIRI N, C. M., ZUMA K, BLAAUW D, GOUDGE J, DWANE N 2013. Equity in Maternal Health in South Africa: Analysis of Health Service Access and Health Status in a National Household Survey. . *PLOS ONE,* 8**,** e73864.

COHEN, M. S., CHEN, Y. Q., MCCAULEY, M., GAMBLE, T., HOSSEINIPOUR, M. C., KUMARASAMY, N., HAKIM, J. G., KUMWENDA, J., GRINSZTEJN, B., PILOTTO, J. H. S., GODBOLE, S. V., MEHENDALE, S., CHARIYALERTSAK, S., SANTOS, B. R., MAYER, K. H., HOFFMAN, I. F., ESHLEMAN, S. H., PIWOWAR-MANNING, E., WANG, L., MAKHEMA, J., MILLS, L. A., DE BRUYN, G., SANNE, I., ERON, J., GALLANT, J., HAVLIR, D., SWINDELLS, S., RIBAUDO, H., ELHARRAR, V., BURNS, D., TAHA, T. E., NIELSEN-SAINES, K., CELENTANO, D., ESSEX, M. & FLEMING, T. R. 2011. Prevention of HIV-1 Infection with Early Antiretroviral Therapy. *The New England journal of medicine,* 365**,** 493-505.

COUNCIL, S. A. N. A. 2013. National Strategic Plan for HIV Prevention, Care and Treatment for Sex Workers. Pretoria: SANAC.

DEPARTMENT OF HEALTH, S. A., AND SOUTH AFRICAN NATIONAL AIDS COUNCI MARCH 2016 2016. South African HIV and TB Investment Case - Summary Report Phase 1. Pretoria SADOH

DOHERTY, T., TABANA, H., JACKSON, D., NAIK, R., ZEMBE, W., LOMBARD, C., SWANEVELDER, S., FOX, M. P., THORSON, A., EKSTROM, A. M. & CHOPRA, M. 2013. Effect of home based HIV counselling and testing intervention in rural South Africa: cluster randomised trial. *Bmj,* 346**,** f3481.

FATTI, G., MEINTJES, G., SHEA, J., ELEY, B. & GRIMWOOD, A. 2012. Improved survival and antiretroviral treatment outcomes in adults receiving community-based adherence support: 5-year results from a multicentre cohort study in South Africa. *J Acquir Immune Defic Syndr,* 61**,** e50-8.

FATTI, G., SHAIKH, N., ELEY, B. & GRIMWOOD, A. 2014. Improved virological suppression in children on antiretroviral treatment receiving community-based adherence support: a multicentre cohort study from South Africa. *AIDS Care,* 26**,** 448-53.

FELDBLUM, P. J., HATZELL, T., VAN DAMME, K., NASUTION, M., RASAMINDRAKOTROKA, A. & GREY, T. W. 2005. Results of a randomised trial of male condom promotion among Madagascar sex workers. *Sex Transm Infect,* 81**,** 166-73.

FRONTIERES, M. S. 2016. Bending the Curves of the HIV/TB Epidemic in Kwazulu-Natal B. South Africa: MSF.

GEIBEL, S., KING'OLA, N., TEMMERMAN, M. & LUCHTERS, S. 2012. The impact of peer outreach on HIV knowledge and prevention behaviours of male sex workers in Mombasa, Kenya. *Sex Transm Infect,* 88**,** 357-62.

GRIMWOOD, A., FATTI, G., MOTHIBI, E., MALAHLELA, M., SHEA, J. & ELEY, B. 2012. Community adherence support improves programme retention in children on antiretroviral treatment: a multicentre cohort study in South Africa. *J Int AIDS Soc,* 15**,** 17381.

HEALTH, D. O. 2016. SADHS South Africa Demographic and Health Survey 2016. Key Indicator Report. Stats SA.

IGUMBOR, J. O., SCHEEPERS, E., EBRAHIM, R., JASON, A. & GRIMWOOD, A. 2011. An evaluation of the impact of a community-based adherence support programme on ART outcomes in selected government HIV treatment sites in South Africa. *AIDS Care,* 23**,** 231-6.

JOHNSON, L. F., HALLETT, T. B., REHLE, T. M. & DORRINGTON, R. E. 2012. The effect of changes in condom usage and antiretroviral treatment coverage on human immunodeficiency virus incidence in South Africa: a model-based analysis. *J R Soc Interface,* 9**,** 1544-54.

KEGELES, S. M., HAYS, R. B. & COATES, T. J. 1996. The Mpowerment Project: a community-level HIV prevention intervention for young gay men. *American Journal of Public Health,* 86**,** 1129-1136.

KERRIGAN, D., KENNEDY, C. E., MORGAN-THOMAS, R., REZA-PAUL, S., MWANGI, P., WIN, K. T., MCFALL, A., FONNER, V. A. & BUTLER, J. 2015. A community empowerment approach to the HIV response among sex workers: effectiveness, challenges, and considerations for implementation and scale-up. *Lancet,* 385**,** 172-85.

KIM, M. H., AHMED, S., BUCK, W. C., PREIDIS, G. A., HOSSEINIPOUR, M. C., BHALAKIA, A., NANTHURU, D., KAZEMBE, P. N., CHIMBWANDIRA, F., GIORDANO, T. P., CHIAO, E. Y., SCHUTZE, G. E. & KLINE, M. W. 2012. The Tingathe programme: a pilot intervention using community health workers to create a continuum of care in the prevention of mother to child transmission of HIV (PMTCT) cascade of services in Malawi. *J Int AIDS Soc,* 15 Suppl 2**,** 17389.

KIPP, W., KONDE-LULE, J., SAUNDERS, L. D., ALIBHAI, A., HOUSTON, S., RUBAALE, T., SENTHILSELVAN, A. & OKECH-OJONY, J. 2012. Antiretroviral treatment for HIV in rural Uganda: two-year treatment outcomes of a prospective health centre/community-based and hospital-based cohort. *PLoS One,* 7**,** e40902.

KIPP, W., KONDE-LULE, J., SAUNDERS, L. D., ALIBHAI, A., HOUSTON, S., RUBAALE, T., SENTHILSELVAN, A., OKECH-OJONY, J. & KIWEEWA, F. 2010. Results of a Community-Based Antiretroviral Treatment Program for HIV-1 Infection in Western Uganda. *Current HIV Research,* 8**,** 179-185.

LANGUZA, N., LUSHABA, T., MAGINGXA, N., MASUKU, M. & NGUBO, T. 2011. Community health workers: a brief description of the HST experience. *Durban: Health Systems Trust*.

LE ROUX, I. M., TOMLINSON, M., HARWOOD, J. M., O'CONNOR, M. J., WORTHMAN, C. M., MBEWU, N., STEWART, J., HARTLEY, M., SWENDEMAN, D., COMULADA, W. S., WEISS, R. E. & ROTHERAM-BORUS, M. J. 2013. Outcomes of home visits for pregnant mothers and their infants: a cluster randomized controlled trial. *Aids,* 27**,** 1461-71.

LILIAN, R. R., KALK, E., TECHNAU, K. G. & SHERMAN, G. G. 2013. Birth diagnosis of HIV infection in infants to reduce infant mortality and monitor for elimination of mother-to-child transmission. *Pediatr Infect Dis J,* 32**,** 1080-5.

LUQUE-FERNANDEZ MA, V. C. G., GOEMAERE E, HILDERBRAND K, SCHOMAKER M, MANTANGANA N, MATHEE S, DUBULA V, FORD N, HERNÁN MA, BOULLE A 2013. Effectiveness of Patient Adherence Groups as a Model of Care for Stable Patients on Antiretroviral Therapy in Khayelitsha, Cape Town, South Africa. *PLOS ONE,* 8**,** e56088.

M. VANDENDYCK, M. M., M. MUBANGA, S. MAKHAKHE, S. JONCKHEREE, A. SHROUFI, T. DECROO 2014. Community antiretroviral therapy groups (CAGs) in Nazareth, Lesotho: the way forward for an effective community model for HIV care? *20th International AIDS Conference.* Melbourne, Australia.

MARSEILLE, E., KAHN, J. G., PITTER, C., BUNNELL, R., EPALATAI, W., JAWE, E., WERE, W. & MERMIN, J. 2009. The Cost-Effectiveness of Home-Based Provision of Antiretroviral Therapy in Rural Uganda. *Applied health economics and health policy,* 7**,** 229-243.

MASSYN N, P. N., ENGLISH R, PADARATH A, BARRON P, DAY C, EDITORS 2016. District Health Barometer 2015/2016. Durban: Health Systems Trust.

MENZIES, N., ABANG, B., WANYENZE, R., NUWAHA, F., MUGISHA, B., COUTINHO, A., BUNNELL, R., MERMIN, J. & BLANDFORD, J. M. 2009. The costs and effectiveness of four HIV counseling and testing strategies in Uganda. *Aids,* 23**,** 395-401.

MERMIN, J., WERE, W., EKWARU, J. P., MOORE, D., DOWNING, R., BEHUMBIIZE, P., LULE, J. R., COUTINHO, A., TAPPERO, J. & BUNNELL, R. 2008. Mortality in HIV-infected Ugandan adults receiving antiretroviral treatment and survival of their HIV-uninfected children: a prospective cohort study. *The Lancet,* 371**,** 752-759.

MWAI, G. W., MBURU, G., TORPEY, K., FROST, P., FORD, N. & SEELEY, J. 2013. Role and outcomes of community health workers in HIV care in sub-Saharan Africa: a systematic review. *Journal of the International AIDS Society,* 16**,** 18586.

MYER, L., CARTER, R. J., KATYAL, M., TORO, P., EL-SADR, W. M. & ABRAMS, E. J. 2010. Impact of Antiretroviral Therapy on Incidence of Pregnancy among HIV-Infected Women in Sub-Saharan Africa: A Cohort Study. *PLoS Medicine,* 7**,** e1000229.

NAIK, R., TABANA, H., DOHERTY, T., ZEMBE, W. & JACKSON, D. 2012. Client characteristics and acceptability of a home-based HIV counselling and testing intervention in rural South Africa. *BMC Public Health,* 12**,** 824.

NEUPANE, S., ODENDAAL, W., FRIEDMAN, I., JASSAT, W., SCHNEIDER, H. & DOHERTY, T. 2014. Comparing a paper based monitoring and evaluation system to a mHealth system to support the national community health worker programme, South Africa: an evaluation. *BMC Med Inform Decis Mak,* 14**,** 69.

NSIBANDE, D., DOHERTY, T., IJUMBA, P., TOMLINSON, M., JACKSON, D., SANDERS, D. & LAWN, J. 2013. Assessment of the uptake of neonatal and young infant referrals by community health workers to public health facilities in an urban informal settlement, KwaZulu-Natal, South Africa. *BMC Health Serv Res,* 13**,** 47.

NUWAHA, F., KASASA, S., WANA, G., MUGANZI, E. & TUMWESIGYE, E. 2012. Effect of home-based HIV counselling and testing on stigma and risky sexual behaviours: serial cross-sectional studies in Uganda. *J Int AIDS Soc,* 15**,** 17423.

SABAPATHY K, V. D. B. R., FIDLER S, HAYES R, FORD N 2012. Uptake of Home-Based Voluntary HIV Testing in Sub-Saharan Africa: A Systematic Review and Meta-Analysis. *PLoS Med,* 9**,** e1001351. .

SALAM, R. A., HAROON, S., AHMED, H. H., DAS, J. K. & BHUTTA, Z. A. 2014. Impact of community-based interventions on HIV knowledge, attitudes, and transmission. *Infectious Diseases of Poverty,* 3**,** 26-26.

SANAC 2017. South African National Strategic Plan on HIV, TB and STIs 2017-2022. SANAC.

SANJANA, P., TORPEY, K., SCHWARZWALDER, A., SIMUMBA, C., KASONDE, P., NYIRENDA, L., KAPANDA, P., KAKUNGU-SIMPUNGWE, M., KABASO, M. & THOMPSON, C. 2009. Task-shifting HIV counselling and testing services in Zambia: the role of lay counsellors. *Hum Resour Health,* 7**,** 44.

SCHUTTNER, L., SINDANO, N., THEIS, M., ZUE, C., JOSEPH, J., CHILENGI, R., CHI, B. H., STRINGER, J. S. A. & CHINTU, N. 2014. A Mobile Phone-Based, Community Health Worker Program for Referral, Follow-Up, and Service Outreach in Rural Zambia: Outcomes and Overview. *Telemedicine Journal and e-Health,* 20**,** 721-728.

SCHWARTZ, S. R., MEHTA, S. H., TAHA, T. E., REES, H. V., VENTER, F. & BLACK, V. 2012. High pregnancy intentions and missed opportunities for patient-provider communication about fertility in a South African cohort of HIV-positive women on antiretroviral therapy. *AIDS Behav,* 16**,** 69-78.

SELKE, H. M., KIMAIYO, S., SIDLE, J. E., VEDANTHAN, R., TIERNEY, W. M., SHEN, C., DENSKI, C. D., KATSCHKE, A. R. & WOOLS-KALOUSTIAN, K. 2010. Task-shifting of antiretroviral delivery from health care workers to persons living with HIV/AIDS: clinical outcomes of a community-based program in Kenya. *J Acquir Immune Defic Syndr,* 55**,** 483-90.

SMITH, J. A., SHARMA, M., LEVIN, C., BAETEN, J. M., VAN ROOYEN, H., CELUM, C., HALLETT, T. B. & BARNABAS, R. V. 2015. Cost-effectiveness of community-based strategies to strengthen the continuum of HIV care in rural South Africa: a health economic modelling analysis. *Lancet HIV,* 2**,** e159-68.

SUTHAR, A. B., FORD, N., BACHANAS, P. J., WONG, V. J., RAJAN, J. S., SALTZMAN, A. K., AJOSE, O., FAKOYA, A. O., GRANICH, R. M., NEGUSSIE, E. K. & BAGGALEY, R. C. 2013. Towards universal voluntary HIV testing and counselling: a systematic review and meta-analysis of community-based approaches. *PLoS Med,* 10**,** e1001496.

TABANA, H., NKONKI, L., HONGORO, C., DOHERTY, T., EKSTRÖM, A. M., NAIK, R., ZEMBE-MKABILE, W., JACKSON, D. & THORSON, A. 2015. A Cost-Effectiveness Analysis of a Home-Based HIV Counselling and Testing Intervention versus the Standard (Facility Based) HIV Testing Strategy in Rural South Africa. *PLoS ONE,* 10**,** e0135048.

TANSER, F., BARNIGHAUSEN, T., GRAPSA, E., ZAIDI, J. & NEWELL, M. L. 2013. High coverage of ART associated with decline in risk of HIV acquisition in rural KwaZulu-Natal, South Africa. *Science,* 339**,** 966-71.

TORPEY KE, K. M., MUTALE LN, KAMANGA MK, MWANGO AJ, SIMPUNGWE J, SUZUKI C, MUKADI YD 2008. Adherence Support Workers: A Way to Address Human Resource Constraints in Antiretroviral Treatment Programs in the Public Health Setting in Zambia. *PLOS ONE,* 3.

UWIMANA, J., ZAROWSKY, C., HAUSLER, H., SWANEVELDER, S., TABANA, H. & JACKSON, D. 2013. Community-based intervention to enhance provision of integrated TB-HIV and PMTCT services in South Africa. *Int J Tuberc Lung Dis,* 17**,** 48-55.

VAN ROOYEN, H., BARNABAS, R. V., BAETEN, J. M., PHAKATHI, Z., JOSEPH, P., KROWS, M., HONG, T., MURNANE, P. M., HUGHES, J. & CELUM, C. 2013. High HIV testing uptake and linkage to care in a novel program of home-based HIV counseling and testing with facilitated referral in KwaZulu-Natal, South Africa. *J Acquir Immune Defic Syndr,* 64**,** e1-8.

VENTER, W. F., KAISER, B., PILLAY, Y., CONRADIE, F., GOMEZ, G. B., CLAYDEN, P., MATSOLO, M., AMOLE, C., RUTTER, L., ABDULLAH, F., ABRAMS, E. J., CASAS, C. P., BARNHART, M., PILLAY, A., POZNIAK, A., HILL, A., FAIRLIE, L., BOFFITO, M., MOORHOUSE, M., CHERSICH, M., SERENATA, C., QUEVEDO, J. & LOOTS, G. 2016. Cutting the cost of South African antiretroviral therapy using newer, safer drugs. *S Afr Med J,* 107**,** 28-30.

WARIKI, W. M., OTA, E., MORI, R., KOYANAGI, A., HORI, N. & SHIBUYA, K. 2012. Behavioral interventions to reduce the transmission of HIV infection among sex workers and their clients in low- and middle-income countries. *Cochrane Database Syst Rev***,** Cd005272.

WEIDLE, P. J., WAMAI, N., SOLBERG, P., LIECHTY, C., SENDAGALA, S., WERE, W., MERMIN, J., BUCHACZ, K., BEHUMBIIZE, P., RANSOM, R. L. & BUNNELL, R. 2006. Adherence to antiretroviral therapy in a home-based AIDS care programme in rural Uganda. *The Lancet,* 368**,** 1587-1594.

WESTREICH, D., MASKEW, M., RUBEL, D., MACDONALD, P., JAFFRAY, I. & MAJUBA, P. 2012. Incidence of pregnancy after initiation of antiretroviral therapy in South Africa: a retrospective clinical cohort analysis. *Infect Dis Obstet Gynecol,* 2012**,** 917059.

WILSON, D. P., LAW, M. G., GRULICH, A. E., COOPER, D. A. & KALDOR, J. M. 2008. Relation between HIV viral load and infectiousness: a model-based analysis. *Lancet,* 372**,** 314-20.

WOUTERS, E., VAN LOON, F., VAN RENSBURG, D. & MEULEMANS, H. 2009. Community support and disclosure of HIV serostatus to family members by public-sector antiretroviral

treatment patients in the Free State Province of South Africa. *AIDS Patient Care STDS,* 23**,** 357-64.

ZACHARIAH, R., TECK, R., BUHENDWA, L., LABANA, S., CHINJI, C., HUMBLET, P. & HARRIES, A. D. 2006. How can the community contribute in the fight against HIV/AIDS and tuberculosis? An example from a rural district in Malawi. *Trans R Soc Trop Med Hyg,* 100**,** 167-75.

TB

South Africa is one of the countries with the highest burden of TB, with an incidence of 431,000 first treatments in 2015 (NSP, 2017), an incidence which has increased by 400% over the past 15 years, largely due to the increased risk of developing TB amongst HIV patients. TB cure rates have been improving partly due to the presence of CHWs who assist to improve case-finding and retention in care. The goal in the National Strategic Plan is to improve coverage rate and move to a 90% cure rate. A strong CHW program can assist in the pursuit of this goal. Interventions by CHWs are however impaired by their patchy deployment across the country and their under resourcing. This section looks at the potential impact and costs of a well performing CHW platform.

CHW TB case-finding

Numerous studies have emphasized the contribution of CHWs in TB active case finding (ACF). ACF in turn increases the number of TB patients on treatment, reducing transmission and consequently reducing TB incidence, DALYs and deaths. Currently 63% of patients infected with TB are in treatment. (SANAC, 2017)

Flick et al. showed that intensified tuberculosis case finding by community health workers was associated with a dramatic (20-fold) increase in TB case detection at a very busy antiretroviral therapy (ART) clinic in rural Malawi. (R. Flick, 2016)

The Zamstar study compared 2 interventions to assess the impact of household level intervention on TB transmission and prevalence. In the first intervention the community-based enhanced case finding (ECF) focused on community-wide actions: use of media, sputum collection points in the community including schools, sport events and fashion shows and fast track collection points in clinics. In the second intervention patients received, in addition to ECF related activities, household level counselling and screening. In the intervention with household visits TB transmission rate reduced by 55% (p=0.063) over 3 years and TB prevalence by 12%. No significant difference was observed in the ECF only group.(Ayles et al., 2013)

A South African study followed a cohort of infants randomised to screening or passive case finding, and found that screening increased case finding by 2.6 times. In the study, ACF provided the first investigation for 77% of smear-positive participants, despite the fact that all participants were symptomatic and lived within 2 km of a primary clinic. The authors add that this finding adds to

accumulating evidence that the slow rate at which patients with tuberculosis report to health facilities is a major rate-limiting step in global efforts to control tuberculosis.(Moyo et al., 2010)

In Brazil, in a pair-matched, cluster-randomised trial, Miller & al compared household symptom screening and spot sputum collection (Arm 1) vs. distribution of an educational pamphlet (Arm 2) in a large Brazilian favela. The case identification rate in Arm 1 was 934/100,000 person-years (py) vs. 604/100,000 py in Arm 2 (RR 1.55, 95%CI 1.10-1.99). An increase of 55% in case detection.(Miller et al., 2010)

In another South African study, Gilbert & al assessed the impact of TB/HIV screening by CHWs in rural areas. They compared the status quo TB/HIV control (Xpert implementation, 36 months of Isoniazid preventive therapy (IPT) for HIV-infected individuals on ART, and MDR-TB care decentralisation) with a situation where screening is done at home and the same follow-up linkage to care. In the status quo scenario, annual total TB incidence would be reduced from 868 per 100,000 to 298 cases per 100,000 population after 10 years. When the community-based TB/HIV screening and linkage to care intervention was implemented under current 36 months IPT guidelines, annual total TB incidence was reduced to between 274 per 100,000 to 233 cases per 100,000 population, for screening frequencies between once every two years and every six months. The authors showed the yearly screening intervention to be very cost-effective at R2,700 per DALY averted, and a GDP per capita of R78,254. In the study the screening team was composed of a nurse, 2 CHWs and 3 counsellors. CHWs currently can do sputum collection but not HIV testing.(Gilbert et al., 2016)

In a study in Barcelona (Spain) Ospina et al evaluated the effectiveness of CHWs intervention to improve contact tracing among immigrants. Contact tracing was performed on 65,7% of smear-positive cases during the pre-intervention period compared to 81.6% of smear-positive TB cases during the intervention period ($p < 0.001$). They conclude that the effectiveness of contact tracing for TB control in areas with high immigration can be improved by incorporating CHWs who act as translators, cultural mediators and facilitators who accompany cases and contacts through treatment and follow-up.(Ospina et al., 2012)

In a 2013 systematic review of the benefits of ACF for TB, the authors concluded that the individual and community-level benefits from active screening for TB were uncertain. However, the article reports on three studies which address the question 'Does screening for tuberculosis disease increase the number of tuberculosis cases detected"? The studies were in Netherlands and Czechoslovakia, clearly a different profile from sub-Sahara Africa. The authors acknowledge "It is difficult to assess how the results from these 2 historic studies compare with the current situation in high TB prevalence countries. Despite these limitations these are the only studies evaluating mass screening over prolonged periods of time" (Kranzer et al., 2013)

CHWs and TB treatment

Numerous studies have shown the impact of CHWs on treatment success and reduced costs.

In a systematic review of trials assessing the impact of Lay Health Workers, Lewin et al identified three studies on TB meeting the criteria of the review (Clarke,2005; Lwilla, 2003; Zwarenstein,

2000), two of them from South Africa and one from Tanzania (Lwilla, 2003). One (Zwarenstein, 2000) was conducted in an urban formal setting, while the remaining two were located in rural settings.(Lewin et al., 2005)

In the South African Clarke et al study, patients assigned to lay health workers reported a significantly higher treatment completion rate (18.7%) and the lay health worker intervention resulted in an 8% higher case finding rate. In the other South African study (Zwarenstein & al), all groups, including patients assigned to a lay health worker (LHW), those attending the clinic and those self-supervising, achieved similar outcomes. New patients report significantly higher benefits from LHW supervision (LHW vs clinic nurse: risk difference 24.2%, 95%CI 6– 42.5, LHW vs. self-supervision 39.1%, 95%CI 17.8–60.3) as do female patients (LHW vs. clinic nurse 48.3%, 95%CI 22.8–73.8, LHW vs. self-supervision 32.6%, 95%CI 6.4–58.7)

In the Tanzania study, Lwilla et al. compared a facility-based DOTS strategy to a community-based strategy, and found no significant difference in conversion and cure rates between the two interventions. [M-H pooled odds ratio (OR) 0.62; 95% confidence interval (CI) 0.23, 1.71 and OR = 1.58; 95% CI 0.32, 7.88, respectively] suggesting that community strategies can be successfully implemented in areas where access to a heath facility is challenged.

In South Africa, Sinanovic et al conducted a cost-effectiveness analysis comparing treatment for new smear-positive pulmonary and retreatment TB patients in two similar townships, one providing clinic-based-care with community-based observation options available for its TB patients and one providing clinic-based care only, with no community-based observation of treatment. Costs were assessed from a societal perspective. The cost per patient treated was lower when DOTs were supervised in the community by CHWs than when DOTs took place at the clinic: 36% lower for first treatment and 23% lower for retreatments. In addition the success rate was higher with CHWs based DOTs: 68% vs. 64% and 58% vs. 52% for new and retreatment patients, respectively. As a consequence the cost per successful treatment was 70% lower for first treatment and 62% lower for retreatment.(Sinanovic et al., 2003)

These findings are similar to those of a study in Tanzania. Wandwalo et al compared the total cost of treating a patient with conventional health facility based DOT and community based DOT. Community based DOT reduced cost by 35%. Cost fell by 27% for health services and 72% for patients. Community based DOT was more cost-effective at US$ 128 per patient successfully treated compared to US$ 203 for a patient successfully treated with health facility based DOT.(Wandwalo et al., 2005)

In a South African study on farms, Clarke & al did an RCT with a cost-effectiveness study. The control arm was implementing the current TB control program and the intervention added lay health workers (LHWs) to the current programme. The observed cost reduction in the LHW arm was 74% per case detected and cured. Interventions farms reached 83% successful treatment completion rate and control farms 65%. (Marina Clarke, 2016)

In a paper on TB control in South Africa Churchyard et al commented that the country's treatment success rate among new smear-positive and smear negative/extra-pulmonary TB patients has improved to 79% and 76% respectively, largely as a result of an increase in cure rates and a decline

in the treatment default rate following the introduction of community-based tracing teams. (Churchyard et al., 2014)

Modelling

In order to quantify the impact for South Africa of CHWs-led interventions including active TB case finding and treatment-related support including treatment and adherence counseling and defaulter tracing, we modelled the difference in deaths averted, disability adjusted life years (DALYs) averted, and cost savings due to avoided transmission, and reduction in service delivery costs through the provision of community-based DOTS by opposition to facility-based DOTS.

Our model compares the current situation in South Africa with a scenario where case finding is increased through CHWs through home visits and contact tracing, translating into a 10% higher TB treatment coverage and in which TB cure rate is improved by 10%. These 10% increases are conservative estimates as evidence provided through the literature review above demonstrates even higher potential through CHW-led interventions.

The modelling of the current situation is based on the new TB cases incidence in 2015 from the National Strategic Plan 2017 for HIV/AIDS, TB and STIs (NSP) 2017(SANAC, 2017), the TB treatment coverage rate and the case fatality rate (CFR) from the 2015 WHO World TB report(Organization, 2016), the treatment success rate from the District Health Barometer(Massyn N, 2016), and the proportion of HIV positive patients from the NSP. Data related to transmission rates and percentage of infectious contacts converting into TB infections was derived from Dye et al, 1999(Dye, 1999). Average age at TB treatment (36) was calculated from the 2015 national TB register. Disability weights for TB patients HIV positive and negative from the Global Burden of Disease.(Kassebaum et al., 2015) Percentages of 1st and repeat treatment patient becoming MDR was drawn from the NSP. Cost data for 1st TB treatment with and without CHWs was extracted and updated for inflation from Sinanovic (Sinanovic et al., 2003) and cost data for MDR treatment combining hospitalization and ambulatory treatment was extracted from decentralised hospital treatment in KZN (Loveday M, under review). Finally we adapted and extended the PSI impact calculator to South Africa.(International, 2017)

Results

We refer to the current situation as “Current” and to the setting in which treatment coverage is increased by 10% and the treatment success rate increases by 10% due to well performing CHW interventions, as “Scenario”.

The Current incidence of new cases is 431,000, the treatment coverage rate is 63% and the treatment success rate is 77.4%. Under the new Scenario, the incidence of TB in year 1 is the same as the current incidence of 431,000, the coverage rate increases to73% and the treatment success rate increases to 87.4%. In year 1, the number of patients on treatment would be 16% higher in the new Scenario than in the Current and the number of successful treatments would be 30.8% higher.

Deaths and DALYS averted

If patients were not treated successfully (treatment failure), 22% of them would die (WHO, 2016). In addition, without successful treatment 14% of those who come in contact with TB patients who remain infectious would contract TB, 22% of whom would die. The number of deaths averted through successful treatment (incidence*CFR*Success rate) in Year 1 amounts to 55,203 in the Current scenario and 72,230 in the new Scenario; this amount to 30.8% more deaths averted under the new Scenario. Over a 10 year period the cumulative deaths averted would amount to 368,183 under the Current scenario and 428,825 in the new Scenario; this would translate into 16.4% more deaths averted in the new Scenario over 10 years. The percentage difference in deaths averted between the two scenarios for the 1st year and cumulatively over 10 years are not identical because the incidence of TB changes each year with reduced TB transmission. Combining the averted discounted life years lost and years lived with disability due to the interventions , the number of DALYs averted would amount to 912,672 in year 1 under the Current scenario and to 1,194,174 under the new Scenario; this reflects 31% more DALYs averted under the new Scenario. Over a 10 year period, 1 million additional DALYs would be averted under implementation of the new Scenario compared to the Current one.

Table 4. TB Deaths and DALYs averted by CHWs interventions

		Current			Scenario	
		2015	Cumulative over 10 Years		2015	Cumulative over 10 Years
	Incidence new cases	431,300			431,300	
Treatment	Treatment Coverage	63%			73%	
	Success Rate	77.4%			87.4%	
	TB on Treatment	271,719			314,849	
	Case fatality Rate	22%			22%	
	Deaths averted through successful treatment	46,268			60,539	
Reduced Transmission	Infectious contacts avoided	290,102			379,581	
	% progressing to TB	14%			14%	
	new infections averted	40,614			53,141	
	Deaths averted through diminished transmission	8,935			11,691	
Total deaths averted		55,203	368,183		72,230	428,825
Additional deaths averted in Scenario					17,027	60,642
Total DALYS averted		912,672	6,087,121		1,194,174	7,089,713
Additional DALYs averted in Scenario					281,502	1,002,592

For every 1% increase in case finding, 14,487 DALYs would be averted in year 1. For no change in case finding but a 1% increase in success rates 11,792 DALYs would be averted. For a combined 1% increase in case finding and 1% increase in success rate 28,150 DALYS would be averted. These findings show that a 1% increase in case finding has a bigger health impact than a 1% increase in success rate and that the combination of the 2 interventions has a health impact larger than the addition of the 2 individual interventions. This speaks to the need for an integrated strategy for TB patient support.

Impact of TB treatment on MDR

Successful treatment of TB avoids conversion to MDR TB, and avoided TB transmission also translates into fewer MDR incident cases. According to the NSP, 1,8% of 1st treatments and 6.7% of retreatments will become MDR (in a conservative approach we use these proportions which are lower than the WHO report which puts these ratios at 3.5% and 7.3% respectively). The number of MDR cases avoided through successful treatment and reduced transmission would amount in year 1 to 14,865 under the Current scenario and 19,669 in the new Scenario, or 32% more MDR cases avoided under the new Scenario. Of these, we assume that under the current scenario, MDR treatment coverage would be 60% while it would rise to 65% under the new Scenario due to higher MDR case finding with CHWs.

These findings are conservative as the further avoided transmission from MDR and XDR patients has not been quantified. This was not included in the calculations as no information could be found by the authors on the transmission rate by MDR and XDR patients.

Table 5. Impact on MDR cases

	Current			Scenario	
	2015	Cumulative over 10 Years		2015	Cumulative over 10 Years
Impact of reduced transmission on MDR TB					
Avoided new infections	40,614			53,141	
Treatment coverage	63%			73%	
Avoided new treatments	25,587			38,793	
*% new treatment	75%			75%	
% repeat treatment	25%			25%	
New TB cases avoided	19,190			29,095	
% becoming MDR	1.80%			1.80%	
Repeat Treatment avoided	6,397			9,698	
% becoming MDR	6.70%			6.70%	
No MDR cases avoided	774	5,162		1,173	6,967
Impact of successful treatment on MDR TB					
Number successful treatments	210,311			275,178	
Number retreatment avoided	210,311			275,178	
% retreatments becoming MDR	6.70%			6.70%	
Number MDR avoided	14,091	93,979		18,437	125,239
Total MDRs avoided	14,865	99,141		19,610	132,205
% MDR in treatment	60%			65%	
Number MDR treatments avoided	8,919			12,747	

Costing

As per the distribution of home visits CHWs would spend 8% of their time on TB (Table 15), excluding TB/HIV comorbidities which are included in the AIDs section. The CHWs cost of implementing the new Scenario would thus amount to R722 million a year.

If TB patients receive DOTs in clinics, the heath system cost per patient treated would be R6,290; if DOTs were delivered by CHWs in the community this cost would amount to R4,685, excluding CHWs costs. For the patients treated under the Current scenario the total cost would be R1.7 billion, and under the new Scenario, treatment cost would amount to R1.64 billion; this represents

a saving of 4% despite 16% more patients being treated under the new Scenario due to higher case finding. Over 10 years the savings would amount to R1.67 billion.

Additional savings can be achieved through the higher number of avoided MDR treatments in the new Scenario in comparison to the Current one. At a cost of R283,474 per MDR patient treated, the additional savings in the new Scenario, compared to Current one, due to additional MDR cases averted would amount to R1 billion a year, a cumulative R7.5 billion over 10 years.

Combining additional costs and savings under the new Scenario, the addition of the CHW platform for TB would amount to saving of R597 million a year (cumulative R2.9 billion over 10 years), a yearly saving on the TB budget of 10.2%. This saving also averts 281,502 DALYS. This would translate into a saving of R2,121 per additional DALY averted in the new Scenario. According to the WHO an intervention is considered effective if the cost per DALY averted amounts to less than 3 times the GDP per capita and very effective at or below the GDP per capita. This intervention by CHWs is not only very cost effective, it is cost-saving.

Table 6. Cost per TB DALY averted with CHW intervention

COSTS OF CHWS PLATFORM									
Costs of 8% time of CHWs							R	722,001,136	R 6,245,309,830
SAVINGS IN SCENARIO									
TB treatment	Number patients trea	R	271,719	R	1,812,245		R	314,849	R 1,869,232
	Cost clinic only	R	1,709,176,906	R	10,416,850,488				
	Cost clinic + CHWs	R	-				R	1,475,146,539	R 8,757,821,548
	Savings in Scenario						R	234,030,367	R 1,659,028,940
MDR TB treatment	Cost by MDR patient	R	283,474						
	Savings MDR treatme	R	2,528,272,524	R	16,862,408,295		R	3,613,378,739	R 24,359,930,658
	Savings in Scenario						R	1,085,106,215	R 7,497,522,363
Combined costs and savings in Scenario							-R	597,135,445	-R 2,911,241,473
	TB Budget 2016						R	5,827,600,000	
	Impact on TB budget							-10.2%	
Cost per DALY averted							-R	2,121	
GDP per capita								78,254	
Percentage of GDP per capita								-2.7%	

Share of CHW time	8%
Deaths averted:	60,642 over 10 years
DALYs averted:	1 million
Saving by DALY averted	R2,121

References

AYLES, H., MUYOYETA, M., DU TOIT, E., SCHAAP, A., FLOYD, S., SIMWINGA, M., SHANAUBE, K., CHISHINGA, N., BOND, V., DUNBAR, R., DE HAAS, P., JAMES, A., GEY VAN PITTIUS, N. C., CLAASSENS, M., FIELDING, K., FENTY, J., SISMANIDIS, C., HAYES, R. J., BEYERS, N. & GODFREY-FAUSSETT, P. 2013. Effect of household and community interventions on the burden of tuberculosis in southern Africa: the ZAMSTAR community-randomised trial. Lancet, 382, 1183-94.

CHURCHYARD, G. J., MAMETJA, L. D., MVUSI, L., NDJEKA, N., HESSELING, A. C., REID, A., BABATUNDE, S. & PILLAY, Y. 2014. Tuberculosis control in South Africa: successes, challenges and recommendations. S Afr Med J, 104, 244-8.

DYE, C., SCHEELE, S., DOLIN, P., PATHANIA, V. AND RAVIGLIONE, M.C. 1999. Consensus Statement. Global Burden of Tuberculosis: Estimated Incidence, Prevalence, and Mortality by Country. WHO Global Surveillance and Monitoring Project. JAMA, 282, 677-686.

GILBERT, J. A., SHENOI, S. V., MOLL, A. P., FRIEDLAND, G. H., PALTIEL, A. D. & GALVANI, A. P. 2016. Cost-Effectiveness of Community-Based TB/HIV Screening and Linkage to Care in Rural South Africa. PLoS One, 11, e0165614.

INTERNATIONAL, P. S. 2017. PSI Impact Calculator [Online]. Available: http://impactcalculator.psi.org/calculator/200.

KASSEBAUM, N. J., ARORA, M., BARBER, R. M., BHUTTA, Z. A., BROWN, J., CARTER, A., CASEY, D. C., CHARLSON, F. J., COATES, M. M., COGGESHALL, M., CORNABY, L., DANDONA, L., DICKER, D. J., ERSKINE, H. E., FERRARI, A. J., FITZMAURICE, C., FOREMAN, K., FOROUZANFAR, M. H., FULLMAN, N., GETHING, P. W., GOLDBERG, E. M., GRAETZ, N., HAAGSMA, J. A., HAY, S. I., JOHNSON, C. O., KEMMER, L., KHALIL, I. A., KINFU, Y., KUTZ, M. J., KYU, H. H., LEUNG, J., LIANG, X., LIM, S. S., LOZANO, R., MENSAH, G. A., MIKESELL, J., MOKDAD, A. H., MOONEY, M. D., NAGHAVI, M., NGUYEN, G., NSOESIE, E., PIGOTT, D. M., PINHO, C., RANKIN, Z., REINIG, N., SALOMON, J. A., SANDAR, L., SMITH, A., SORENSEN, R. J. D., STANAWAY, J., STEINER, C., TEEPLE, S., TROEGER, C., TRUELSEN, T., VANDERZANDEN, A., WAGNER, J. A., WANGA, V., WHITEFORD, H. A., ZHOU, M., ZOECKLER, L., ABAJOBIR, A. A., ABATE, K. H., ABBAFATI, C., ABBAS, K. M., ABD-ALLAH, F., ABRAHAM, B., ABUBAKAR, I., ABU-RADDAD, L. J., ABU-RMEILEH, N. M. E., ACHOKI, T., ACKERMAN, I. N., ADEBIYI, A. O., ADEDEJI, I. A., ADSUAR, J. C., AFANVI, K. A., AFSHIN, A., AGARDH, E. E., AGARWAL, A., AGARWAL, S. K., AHMED, M. B., KIADALIRI, A. A., AHMADIEH, H., AKSEER, N., AL-ALY, Z., ALAM, K., ALAM, N. K. M., ALDHAHRI, S. F., ALEGRETTI, M. A., ALEMAN, A. V., ALEMU, Z. A., ALEXANDER, L. T., ALI, R., ALKERWI, A. A., ALLA, F., ALLEBECK, P., ALLEN, C., ALSHARIF, U., ALTIRKAWI, K. A., MARTIN, E. A., ALVIS-GUZMAN, N., et al. 2015. Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *The Lancet,* 388**,** 1603-1658.

KRANZER, K., AFNAN-HOLMES, H., TOMLIN, K., GOLUB, J. E., SHAPIRO, A. E., SCHAAP, A., CORBETT, E. L., LONNROTH, K. & GLYNN, J. R. 2013. The benefits to communities and individuals of screening for active tuberculosis disease: a systematic review. *Int J Tuberc Lung Dis,* 17**,** 432-46.

LEWIN, S. A., DICK, J., POND, P., ZWARENSTEIN, M., AJA, G., VAN WYK, B., BOSCH-CAPBLANCH, X. & PATRICK, M. 2005. Lay health workers in primary and community health care. *Cochrane Database Syst Rev***,** Cd004015.

LOVEDAY M, W. K., BESADA D, REDDY T, BRUST J, DESAI H, VOCE A, NGOZO J, RADEBE Z, PADAYATCHI N, DAVIAUD E. under review. MDR-TB patients in KwaZulu-Natal, South Africa: cost-effectiveness of 5 models of care. *EID*.

MARINA CLARKE, J. D., LENNART BOGG 2016. Cost-effectiveness analysis of an alternative tuberculosis management strategy for permanent farm dwellers in South Africa amidst health service contraction. *Scandinavian Journal of Public Health* 34**,** 83-91.

MASSYN N, P. N., ENGLISH R, PADARATH A, BARRON P, DAY C, EDITORS 2016. District Health Barometer 2015/2016. Durban: Health Systems Trust.

MILLER, A. C., GOLUB, J. E., CAVALCANTE, S. C., DUROVNI, B., MOULTON, L. H., FONSECA, Z., ARDUINI, D., CHAISSON, R. E. & SOARES, E. C. 2010. Controlled trial of active tuberculosis case finding in a Brazilian favela. *Int J Tuberc Lung Dis,* 14**,** 720-6.

MOYO, S., VERVER, S., MAHOMED, H., HAWKRIDGE, A., KIBEL, M., HATHERILL, M., TAMERIS, M., GELDENHUYS, H., HANEKOM, W. & HUSSEY, G. 2010. Age-related tuberculosis incidence and severity in children under 5 years of age in Cape Town, South Africa. *Int J Tuberc Lung Dis,* 14**,** 149-54.

ORGANIZATION, W. H. 2016. Global Tuberculosis Report. Geneva: WHO.

OSPINA, J. E., ORCAU, A., MILLET, J. P., SANCHEZ, F., CASALS, M. & CAYLA, J. A. 2012. Community health workers improve contact tracing among immigrants with tuberculosis in Barcelona. *BMC Public Health,* 12**,** 158.

R. FLICK, K. S., A MUNTHALI, A DIMBA, M KIM, P KAZEMBE, M HOSSEINIPOUR, S AHMED 2016. Yield of community health worker-driven intensified case finding for tuberculosis among HIV-positive patients in rural Malawi. *21st International AIDS Conference.* Durban.

SANAC 2017. South African National Strategic Plan on HIV, TB and STIs 2017-2022. SANAC.

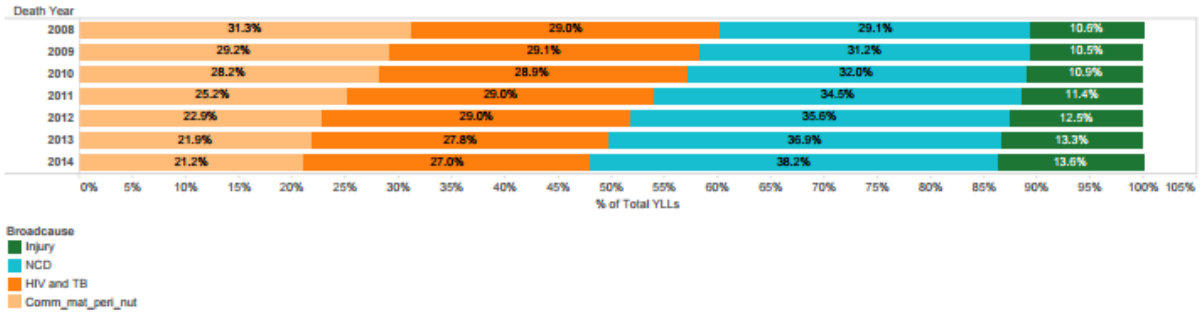
SINANOVIC, E., FLOYD, K., DUDLEY, L., AZEVEDO, V., GRANT, R. & MAHER, D. 2003. Cost and cost-effectiveness of community-based care for tuberculosis in Cape Town, South Africa. *Int J Tuberc Lung Dis,* 7**,** S56-62.

WANDWALO, E., ROBBERSTAD, B. & MORKVE, O. 2005. Cost and cost-effectiveness of community based and health facility based directly observed treatment of tuberculosis in Dar es Salaam, Tanzania. *Cost effectiveness and resource allocation : C/E,* 3**,** 6-6.

Burden of Hypertension and Diabetes in South Africa

Although communicable diseases still impose the largest burden in sub-Saharan Africa, NCDs are projected to become the leading cause of death by 2030.(Farrington, 2013) Nearly half of the population in sub-Saharan Africa already suffers from hypertension, a major contributor to heart attacks and strokes(WHO, 2014).The burden of non-communicable diseases (NCDs) in low and middle income countries (LMIC) is very high and compounds the high burden of infectious diseases.(WHO, 2009) NCDs in South Africa, cardiovascular and kidney disease, diabetes, chronic respiratory conditions, cancer, mental disorders, oral and eye pathologies and musculoskeletal conditions are amongst the leading causes of mortality, and combined, the largest contributors of years of life lost (YLLs). In 2009, NCDs accounted for approximately one third of YLLs nationally(Day et al., 2014), and NCD-related mortality rose by 2010 to account for 36% of deaths.(Nojilana et al., 2016) According to data published by the WHO Global Health Estimates study(WHO, 2013) in 2013, NCDs, including stroke, hypertensive heart disease, diabetes mellitus (DM) and chronic kidney disease accounted for 30% of the 9.5 million deaths and 25.8% of the 675.4 million disability-adjusted life years (DALYs) recorded. By 2015, diabetes was the second leading cause of DALYs in South Africa, following HIV, with ischemic heart disease in 7th place and stroke being the 9th leading cause according to the latest District Health Barometer (Kassebaum, 2016).

Figure 1: Percentage of years of life lost (YLLS) by broad cause, South Africa, 2008-2014



**DHB 2015/2016

Screening Recommendations for Hypertension and Diabetes:

The American Diabetes Association's guideline(2014) recommends that testing to detect type 2 diabetes and prediabetes in asymptomatic people should be considered in adults of any age who are overweight or obese (BMI ≥ 25 kg/m^2) and who have one or more additional risk factors for diabetes. Amongst those without risk factors, testing should begin at the age of 45.

According to the U.S Preventive Services Task Force (USPSTF)(Siu, 2015), screening for diabetes includes screening for abnormal blood glucose as a means to conduct cardiovascular risk assessments for overweight and obese adults aged 40-70.

The Society of Endocrinology Metabolism and Diabetes of South Africa (SEMDSA)(Amod A, 2012) recommends that high risk individuals or those over the age of 45 should be screened every three years if there is normal levels of risk, and more frequently otherwise. High risk individuals include those who are overweight, and have one additional risk factor which may include physical inactivity or hypertension. SEMDSA indicates that any fasting plasma glucose, 2 hour oral glucose tolerance test (OGTT) or HbA1c be used, with the OGTT the preferred method in high-risk individuals.

With regards to hypertension, the USPSTF(Force) recommends screening for high blood pressure in adults aged 18 and older, recommending that ambulatory blood pressure monitoring be used prior to diagnosis. South African Hypertension guidelines do not make explicit mention of screening.(Seedat et al., 2014)

South Africa's National Strategic Plan for NCDs

In response to the growing burden of non-communicable diseases in South Africa, the Department of Health's Strategic Plan for the Prevention and Control of Non-Communicable Diseases 2013-17(Health, 2013) highlights 3 major components:

- Prevent NCDs and promote health and wellness at population, community and individual levels;
- Improve control of NCDs through health systems strengthening and reform;
- Monitor NCDs and their main risk factors and conduct innovative research.

The hypertension and diabetes related 2020 goals and targets are:

- Reduce by at least 25% the relative premature mortality (under 60 years of age) from Non-communicable Diseases by 2020;
- Reduce by 20% tobacco use by 2020;
- Reduce by 20% the per capita consumption of alcohol by 2020;
- Reduce mean population intake of salt to <5 grams per day by 2020
- Reduce by 20% the percentage of people who are overweight/obese by 2020
- Reduce the prevalence of people with raised blood pressure by 20% by 2020 (through lifestyle and medication)
- Increase the prevalence of physical activity (defined as 150 minutes of moderate-intensity physical activity per week, or equivalent) by 10%
- Increase the percentage of people controlled for hypertension, diabetes, and asthma by 30% by 2020 in sentinel sites

The challenge associated with the effective management of patients who are at high risk for NCDs in low-resource settings is limited human and financial resources.(WHO, 2006) In response, the South African Department of Health has acknowledged in their human resources for health strategy(Health, 2012) the need for improved community based care for NCDs and is currently undertaking a re-engineering of its Primary Health Care (PHC) to ensure improvements in service

capacity to manage the ongoing infectious disease challenges in addition to the rising demands from increasing hypertension and other NCDs in light of the limited numbers of doctors and nurses.

Furthermore, the NCD strategic plan recognizes that the successful implementation of the strategy is contingent on the success of the primary healthcare re-engineering process including the renewed focus on community oriented care through the outreach teams

Total health expenditure for diabetes for adults in SSA is projected to increase by approximately 50% between 2010 and 2030.(Zhang et al., 2010) In SA, these costs are projected to be between 1.1 to 2 billion USD in 2030.

Hypertension

Hypertension is a major risk factor for the development of cardiovascular disease, which is the leading cause of NCD-related mortality. Therefore the monitoring and management of hypertension is a critical strategy to understand and control the morbidity and mortality burden associated with this category of disease. (Ferguson and Sattar, 2013, Kaplan, 2007, Yudkin et al., 2010)

According to the latest District Health Barometer(Massyn N, 2016), hypertension prevalence in South Africa was approximately 28.2% in 2015 amongst over 40s, with high inter-provincial variations, with the Northern Cape reporting a prevalence up to 40%. Nationally, the incidence of hypertension has been decreasing consistently between 2011/12 and 2014/15, declining from 22.3 cases per 1000 population to 13.9 cases, however this incidence rose again and was reported as 16.8 cases per 1000 population over the age of 40 by 2015/16. Hypertension prevalence used to be higher in the two least deprived economic quintiles, however the incidence of hypertension is now increasing as socio-economic quintile (SEQ) decreases. Furthermore, adherence to hypertension medication varies significantly from under 10% in the lowest socio-economic status (SES) quintile compared to 80% in the highest quintile.(Schneider et al., 2009) A 3 year screening study run by Project HOPE, an implementing partner of the Lilly Non Communicable Disease (NCD) Partnership programme in South Africa(Paul Rheeder, 2016) revealed similar findings, with overall prevalence of hypertension of 27%, however this rose to 58% among informal settlement participants over the age of 45 in Zandspruit. Furthermore, according to Global Ageing and Adult Health (SAGE) study conducted by the World Health Organization, 75% of male participants and 80% of female participants from South Africa over the age of 50 reported hypertension (>140/90 mmHg) or being prescribed an anti-hypertensive. This reflects one of the highest prevalences globally. (Lloyd-Sherlock et al., 2014) According to the Demographic Health Survey, 46% percent of women and 44% of men are hypertensive based on their diastolic blood pressure being above 140mmHg, their systolic blood pressure being above 90 mmHg or taking antihypertensive medication.(Health, 2016)

The advent of improved drug regimens and expanded access to treatment has translated into HIV/AIDS being regarded as a treatable chronic illness, with the expectation that persons with HIV/AIDS will live longer and lead more active lives. This will increase their exposure to CVD risk including hypertension (Tollman et al., 2008). An increasing number of studies have highlighted

that HIV positive patients have an increased risk of cardiovascular disease, largely due to hypertension. Research has suggested that the prevalence of hypertension amongst HIV positive individuals ranges between 13-49%. Risk factors include age, gender, BMI, immune responses, including activation, inflammation and deficiency associated with HIV and antiretroviral therapy.(van Zoest et al., 2016)

Evidence for CHW/lay workers-related interventions in hypertensive care

A recent review which explored the effectiveness of CHW led interventions in providing care for hypertension demonstrated improvements in keeping appointments, compliance with prescribed regimens, risk reduction, blood pressure control, and related mortality.(Brownstein et al., 2007) All of the studies reviewed were conducted in the U.S and interventions were mostly targeted to minority populations (most commonly African Americans.

Findings of the systematic review have included:

- Positive behavioral changes were found in nine of the ten studies, with four RCTs and one comparison study reporting significant improvements in appointment keeping from 19% to 39% (relative changes) over 12 to 24 months.
- Two RCTs (in which CHWs were used) noted significant improvement associated with adherence to medications when compared with the control group (between-group differences ranged from 8% to 14% at follow-up from 12 to 60 months).
- Another RCT found 26% greater adherence among patients receiving intense CHW interventions.
- A before-and-after study found a 17% improvement in adherence to medication with counselling by CHWs, while a time-series study noted that 86% of CHW-assigned patients were on hypertensive medications
- Nine studies reported positive improvements on blood pressure control; six RCTs, one time-series study and two before-and-after studies.
    - The RCTs demonstrated differences between CHW and control groups ranging from 4% to 46% over 6 to 24 months.
    - In one RCT, patients receiving one CHW home visit vs. 6 visits were equivalent in achieving significant BP control over a 40-month period.
    - In another RCT, the participants receiving the CHW interventions were twice as likely to achieve BP goals
    - In one before-and-after studies, monitoring of BP by CHWs was associated with a significant decrease in diastolic BP of 7 mmHg;
    - In the second before-and-after study, >90% of the patients had their BP under control at 12 months and between 79% and 90% had it under control at 18 months.

Table 7. Summary of hypertension related outcomes with CHWs interventions

Author (year)[ref]	Participant satisfaction	Participant awareness and behavior outcomes and satisfaction	Physiologic measures and health outcomes	Healthcare system outcomes
Becker (2005)19	NR	% taking antihypertensive agents (↑): CBC=17, EPC=9 (p<0.0001);	CBC group was 2 times more likely to achieve blood pressure (95% CI=1.4–3.9) and LDL cholesterol goals (95% CI=1.1–4.2); ↓ %FRS for total CHD: [CBC vs EPC=25.5 vs 3.3 (p<0.0001)]; ↓ % FRS CHD risk among nondiabetic siblings: [CBC vs EPC=27.4 vs 2.3 (p<0.0001)]; ↓ CHD global health risk for CBC compared to no ↓ in EPC (p<0.0001)	
		% taking lipid-lowering agents (↑): CBC=32, EPC=7 (p<0.0001);		
		% current smokers (↓): CBC=–6, EPC=–3 (p<0.0001);		
		% current smokers (↓): CBC=–6, EPC=–3 (p<0.0001);		
		% current smokers (↓): CBC=–6, EPC=–3 (p<0.0001);		
Bloom (1987)20	NR	Those assigned to CHWs were more frequently on medications than those assigned to NP (86% vs 70%)	At T1 58.4% and at T3 78.3% had controlled BP. Mean SBP and DBP difference 7.7 mmHg (T=5.06, p<0.001); 2.84 mmHg (T=3.65, p<0.001). Of 40% improvement, 10% was attributed to physician care, 30% to counseling	NR
Bone (1989)21	NR	Significant improvement in CHW (19%, p<0.001) group at follow-up >2 yr.Patients not keeping follow-up recontacted with 7% improvement (p<0.001). Total improvement in appointment keeping 26%	NR	↑ provider responsiveness to patients' needs; ↑ BP service hours and ↓ fees for BP follow-up visits; CHWs included in the emergency department staff's annual planning meetings
Fedder (2003)22	NR	NR	NR	Healthcare utilization: ↓ ER visits 38% (p value NR); ↓ admissions through the ER 53% (p=0.02); no significant relationship between age, gender, number of CHW contacts, and outcomes
Felix-Aaron (2002)23		Aspects of CHW care rated important: CHW knows job, keeps client alive, gives information on HBP, shows respect, speaks understandably, pays attention	NR	NR
Frate (1985)24, 33	NR	NR	NR	Healthcare utilization: at 12 mo >300 people who were unaware of being HTN or uncontrolled who were enrolled
Hill (2003)25	NR	NR	NR	Proportion of men reporting having a physician or nurse for HTN care among MI ↑ (p<0.05).
Hill (1999)26	NR	NR	NR	Entry into care and remaining in care remained at low rates
Hovell (1984)27	NR	NR	NR	NR
Krieger (1999)28	NR	NR	NR	Follow-up: μ in IG by 39.4% [95% CI=14%–71%, p=0.001]
Levine (1990)29, 36,37	NR	NR	NR	NR
Levine (2003)30	NR	NR	NR	NR
Morisky (1985)31, 34,35,38	NR	NR	NR	NR
Morisky (2002)32	Social support and satisfaction with social support positively related to compliance (r=−0.11, p<0.004)	NR	NR	NR

AA, African Americans; CBC, community-based care; CG, control group; CHD, coronary heart disease; CHW, community health worker; CI, confidence interval; ctrl, control; DBP, diastolic blood pressure; EPC, enhanced primary care; ER, emergency room; FRS, Framingham risk factor; HBP, high blood pressure; HTN, hypertension/hypertensive; I, intervention; LDL, low-density lipoprotein; LI, less intensive; MI, more intensive; mo, months; NP, nurse practitioner; NR, not reported; SBP, systolic blood pressure; T, time; T1, Time 1; T3, Time 3; UC, usual care; WT, weight; yr, years; YBM, young black males.

Screening

A study(Gaziano et al., 2015) aimed at investigating whether community health workers could effectively undertake community-based screenings, with a simple, non-invasive risk prediction indicator in low-income and middle-income countries to predict cardiovascular disease risk as effectively as other health practitioners demonstrated that community health workers can be effectively trained to screen for cardiovascular disease risk and generate scores that are in a high level of agreement with those generated by health professionals.

- 6% of study participants were deemed to be at high risk (>20%) across the entire study and same-day, urgent referrals were provided for 19·3% of them. Of the 4 countries studied, South Africa alone accounted for 69·2% of the urgent and 44·1% of non-urgent referrals.
- 22.4% of those with a generated score had a risk of greater than 10% and 77·6% had a risk of less than 10%, with South Africa reporting the highest proportion of people at high risk.
- Among participants with a cardiovascular disease risk score, only 1% of the community health workers' referral recommendations would have been changed with a physician's review.
- Even with the exclusion of individuals with a previous diagnosis of diabetes, hypertension, or known heart disease, nearly 20% still have a 5-year cardiovascular disease risk greater than or equal to 10%.

Blood pressure control

A longitudinal study was carried out in Bangladesh(Muhammad Ashique Haider Chowdhury, 2016) to examine the effect of community health worker-provided targeted education and regular follow-up of hypertensive patients on health outcomes. The intervention consisted of quarterly group meetings and individual counseling sessions.

At baseline, only half of the total hypertensive patients were aware of their blood pressure status, and about half of those patients had their condition under control. The mean systolic blood pressure of the intervention group declined by 3.3 mmHg at 6 months; and by 10.14 mmHg at month-12, and 10.10 mmHg at month-18. The reduction was also significant for the mean diastolic blood pressure with declines of 1.95 mmHg at month-6; 6.58 mmHg at month-12; and 6.72 mmHg at month-18). Despite a rise in mean systolic and diastolic blood pressure by month 18, the mean DBP at month-24 remained significantly lower (−3.71 mmHg) in comparison to baseline.

A rapid record review(Ndou et al., 2013) of the Gauteng Department of Health's 2008 initiated 'Kgatelopele' programme to improve the management of hypertension and diabetes among patients by home delivery of medication and assessment of basic clinical indicators by CHWs demonstrated that: for patients with hypertension, blood pressure was controlled for a higher proportion of patients on the Kgatelopele programme in comparison with those attending the clinic 21.4% vs. 13.1% of clinic patients. A further comparison amongst who had both hypertension and diabetes found that hypertension was

controlled amongst an even higher proportion of Kgatelopele patients (27.3%) >40% of health checks in comparison with 4.8% of clinic patients.

An intervention consisting of group education sessions delivered by health promoters in community health centers in Cape town (Mash et al., 2014), focusing on diabetes, healthy living and, understanding medication and potential complications found a significant decrease in both systolic (-4.65, 95%CI -9.18- -0.12; P=0.044) and diastolic blood pressure (-3.30, 95%CI -5.35- -1.26; P=0.002) in the intervention group. Furthermore there was a dose related response with those who attended all four sessions had a lower systolic (-4.8 mmHg, 95%CI -8.9- -0.8; P = 0.02) and diastolic blood pressure (-2.5 mmHg, 95% CI -5.1- -0.1, P = 0.06) compared with those who attended fewer sessions. Furthermore, those who attended any sessions reported significantly increased physical activity (1.1 days/week, 95% CI 0.2-2.0; P = 0.02).

Cost effectiveness

A Markov modeling study in South Africa (Gaziano et al., 2014) to determine the benefits and costs of using CHW home visits (2 per year) to improve hypertension adherence for patients aged 25-74 reported the annual cost of the CHW intervention at US$8 per patient and more than 2% reduction in CVD events over a life-time and decreased DALY burden. As a result of reductions in non-fatal CVD events, lifetime costs are only $6.56 per patient. The CHW intervention resulted in an incremental cost-effectiveness ratio of $320/DALY averted. The intervention is cost saving at an annual cost of $6.50 if it achieves a blood pressure reduction of 5 mmHg or greater per patient.

Hypertension Modelling

We built our estimations on two models. Perreault et al's (Perreault et al., 1999) model from Canada calculates the annual death risk for hypertensive at baseline and on treatment. The model is disaggregated by age and sex. The second model by Gaziano et al(Gaziano et al., 2014)assesses the benefits of CHWs home visits to improve adherence to treatment and their impact on non-fatal cardio-vascular incidents.

The prevalence of hypertension stood at 6.3 million in 2013 with an incidence rate of 16.8 per 1000 population over 40.(Massyn N, 2016). 42% of hypertensives are on treatment and we assumed that CHWs increase by 10% the number of people aware of their condition and on treatment, translating into an additional 818,357 hypertensives on treatment over 10 years, of which 15% are controlled.(Gaziano et al., 2014). An intervention consisting of 2 annual home visits per CHW per uncontrolled patient translates into 0,025 DALY averted. For the uncontrolled population this intervention would avert 13,421 DALYs.

In addition, the annual decreased risk of death amongst hypertensives on treatment would translate into 6,588 additional deaths averted over 10 years, averting 52,869 over 10 years. The total number of DALYs averted would be 73,716.

We assume that CHWs spend 10% of their time on hypertensives (Table 15), an equivalent amount of time is allocated to diabetics when in practice the visits are likely to be combined in many cases due to the co-morbidity between these 2 conditions. The cost per DALY averted would amount to R105,051. With a GDP per capita of R78,254 this intervention is cost-effective by WHO thresholds.

Table 8. Modelling of CHWs impact on hypertension

	Standard	CHW	over 10 years
Prevalence	6,300,000	6,300,000	
Incidence	209,286	209,286	
% on treatment	42%	52%	
# on treatment	2,646,000	3,276,000	
Additional on treatment		630,000	818,357
% controlled	15%	22%	
Pop uncontrolled			695,604
Additional DALY averted per patient			0
Additional DALY averted for pop uncontrolled			14,260
Additional deaths averted			6,588
Additional DALYs averted from deaths averted			52,869
Total DALYs averted			73,716
Cumulative costs CHWs			R 7,743,978,620
Cost per DALY averted			R 105,051

Share of CHW time	10%
Deaths averted:	6,588 over 10 years
DALYS averted	73,716
Cost per DALY averted	R105,051

References

2014. Executive summary: Standards of medical care in diabetes--2014. *Diabetes Care,* 37 Suppl 1**,** S5-13.

AMOD A, A.-E. B., BERG GI, BLOM DJ, BROWN SL, CARRIHILL MM, DAVE JA, DISTILLER LA, GANIE YN, GROBLER N, HEILBRUNN AG, HUDDLE KRL, JANSE VAN RENSBURG G, JIVAN D, JOSHI P, KHUTSOANE DT, LEVITT NS, MAY WM, MOLLENTZE WF, MOTALA AA, PARUK IM, PIRIE FJ, RAAL FJ, RAUFF S, RAUBENHEIMER PJ, RANDEREE HAR, RHEEDER P, TUDHOPE L, VAN ZYL DJ, YOUNG M; GUIDELINE COMMITTEE. 2012. The 2012 SEMDSA Guideline for the Management of Type 2 Diabetes (Revised). *Jounral of Endocrinology Metabolish and Diabetes for South Africa* S1-S95.

BROWNSTEIN, J. N., CHOWDHURY, F. M., NORRIS, S. L., HORSLEY, T., JACK, L., JR., ZHANG, X. & SATTERFIELD, D. 2007. Effectiveness of community health workers in the care of people with hypertension. *Am J Prev Med,* 32**,** 435-47.

DAY, C., GROENEWALD, P., LAUBSCHER, R., CHAUDHRY, S., VAN SCHAIK, N. & BRADSHAW, D. 2014. Monitoring of non-communicable diseases such as hypertension in South Africa: challenges for the post-2015 global development agenda. *S Afr Med J,* 104**,** 680-7.

FARRINGTON, P. V. M. A. J. L. 2013. The Challenge of NonCommunicable Diseases and Road Traffic Injuries in Sub-Saharan Africa: An Overview. Washington DC: World Bank.

FERGUSON, L. D. & SATTAR, N. 2013. Reducing cardiovascular disease risk in type 2 diabetes: is the focus on glycaemia warranted? *Diabetes Obes Metab,* 15**,** 387-91.

FORCE, U. P. S. T. *Final Recommendation Statement High Blood Pressure in Adults: Screening* [Online]. Available:

https://www.uspreventiveservicestaskforce.org/Page/Document/RecommendationStatementFinal/high-blood-pressure-in-adults-screening.
HEALTH, D. O. 2012. Human Resources for Health South Africa: HRH Strategy for the Health Sector: 2012/13 – 2016/17. South African Department of Health.
HEALTH, D. O. 2016. SADHS South Africa Demographic and Health Survey 2016. Key Indicator Report. Stats SA.
HEALTH, S. A. D. O. 2013. Strategic Plan for the Prevention and Control of Non-Communicable Diseases 2013-17 *In:* HEALTH, D. O. (ed.). Pretoria.
KAPLAN, N. M. 2007. Vascular outcome in type 2 diabetes: an ADVANCE? *Lancet,* 370**,** 804-5.
KASSEBAUM, N. 2016. Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet,* 388**,** 1603-1658.
LLOYD-SHERLOCK, P., BEARD, J., MINICUCI, N., EBRAHIM, S. & CHATTERJI, S. 2014. Hypertension among older adults in low- and middle-income countries: prevalence, awareness and control. *Int J Epidemiol,* 43**,** 116-28.
MASH, R. J., RHODE, H., ZWARENSTEIN, M., ROLLNICK, S., LOMBARD, C., STEYN, K. & LEVITT, N. 2014. Effectiveness of a group diabetes education programme in under-served communities in South Africa: a pragmatic cluster randomized controlled trial. *Diabet Med,* 31**,** 987-93.
MASSYN N, P. N., ENGLISH R, PADARATH A, BARRON P, DAY C, EDITORS 2016. District Health Barometer 2015/2016. Durban: Health Systems Trust.
NOJILANA, B., BRADSHAW, D., PILLAY-VAN WYK, V., MSEMBURI, W., LAUBSCHER, R., SOMDYALA, N. I., JOUBERT, J. D., GROENEWALD, P. & DORRINGTON, R. E. 2016. Emerging trends in non-communicable disease mortality in South Africa, 1997 - 2010. *S Afr Med J,* 106**,** 58.
PAUL RHEEDER, T. M., STEFAN LAWSON & JULIE BRINK 2016. Diabetes and hypertension screening in Zandspruit, Johannesburg 2012–2014. *South African Family Practice* 58**,** 219-224.
SCHNEIDER, M., BRADSHAW, D., STEYN, K., NORMAN, R. & LAUBSCHER, R. 2009. Poverty and non-communicable diseases in South Africa. *Scand J Public Health,* 37**,** 176-86.
SEEDAT, Y. K., RAYNER, B. L. & VERIAVA, Y. 2014. South African hypertension practice guideline 2014. *Cardiovascular Journal of Africa,* 25**,** 288-294.
SIU, A. L. 2015. Screening for Abnormal Blood Glucose and Type 2 Diabetes Mellitus: U.S. Preventive Services Task Force Recommendation Statement. *Ann Intern Med,* 163**,** 861-8.
TOLLMAN, S. M., KAHN, K., SARTORIUS, B., COLLINSON, M. A., CLARK, S. J. & GARENNE, M. L. 2008. Implications of mortality transition for primary health care in rural South Africa: a population-based surveillance study. *Lancet,* 372**,** 893-901.
VAN ZOEST, R. A., WIT, F. W., KOOIJ, K. W., VAN DER VALK, M., SCHOUTEN, J., KOOTSTRA, N. A., WIERSINGA, W. J., PRINS, M., VAN DEN BORN, B. J. & REISS, P. 2016. Higher Prevalence of Hypertension in HIV-1-Infected Patients on Combination Antiretroviral Therapy Is Associated With Changes in Body Composition and Prior Stavudine Exposure. *Clin Infect Dis,* 63**,** 205-13.
WHO 2006. The world health report 2006. Working together for health. Geneva: World Health Organization.
WHO 2009. 2008–2013 Action plan for the global strategy for the prevention and control of noncommunicable diseases. Geneva: World Health Organization.
WHO 2014. Raised Blood Pressure. World Health Organization.
WHO 2013. Health statistics and health information systems—Global Health Estimates (GHE),.
YUDKIN, J. S., RICHTER, B. & GALE, E. A. 2010. Intensive treatment of hyperglycaemia: what are the objectives? *Lancet,* 376**,** 1462-3.
ZHANG, P., ZHANG, X., BROWN, J., VISTISEN, D., SICREE, R., SHAW, J. & NICHOLS, G. 2010. Global healthcare expenditure on diabetes for 2010 and 2030. *Diabetes Res Clin Pract,* 87**,** 293-301.

Diabetes

More than any other continent, Africa suffers from the combined presence and effects of diabetes together with HIV/AIDS and tuberculosis (TB). The interactions between these conditions and their treatment pose many challenges. Patients with diabetes have been found to have an increased general risk of infection and a two to three times increased risk of developing TB. Some antiretrovirals cause glucose intolerance, predisposing the HIV-positive patient to developing diabetes. Drug interactions between the medications used to treat diabetes and TB reduce each other's effectiveness, making it difficult to treat both conditions in one patient.(Harries et al., 2011, Ottermann, 2010)

South Africa reports a diabetes prevalence of 2.28 million cases in 2015.(Federation, 2015) It has been estimated that another 2.6 million South Africans have impaired glucose tolerance, an early metabolic abnormality that often leads to the eventual development of diabetes The DHIS reports the incidence of diabetes as the number of new cases initiated on treatment per 1000 population, and therefore does not necessarily reflect the true incidence of diabetes in the population. In 2015/16 the incidence of diabetes was measured as 1.7 cases per 1000 population, up from 1.4 cases in 2014/2015. As is the case for hypertension, the incidence of diabetes appeared to be higher amongst the lowest SES quintiles. The rise in diabetes incidence is most likely associated with the rapid urbanization in South Africa and associated changes in sugar intake, decreased physical inactivity and in turn, rise in obesity(Kruger HS, 2005). This is amplified by the social desirability to be overweight(Faber M, 2005), with obesity prevalence among South African women more than three times that of men (30% vs. 7.5%)(Puoane T, 2002).

Stunting in children remains a significant challenge in South Africa, with one in three boys and one in four girls being stunted. (Health, 2016)Furthermore, the prevalence of hypertension, overweight, and obesity are increasing in South Africa 1998, with the latest Demographic Health Survey estimating that 68% of women and 31% of men are overweight or obese. The prevalence of severe obesity among South Africa women is particularly alarming, with one in five women reporting a BMI ≥ 35.0(Health, 2016). In addition, it is estimated that approximately one-third of those with diabetes are undiagnosed(Diabetes Prevention Program Research, 2002). Diabetes management in South Africa appears to be challenged due to a combination of factors including limited use or management guidelines and standardized assessments, low levels of patient awareness around self-care, and low control rates for both blood glucose (16%-49%) and blood pressure (35%-39%). In addition, doctors are reluctant to prescribe insulin, due to fears that patients lack sufficient knowledge and understanding to use it safely.(Steyn K, 2006)

Achieving and maintaining a healthy lifestyle has been proven to be critical to lifelong diabetes management and positive long-term outcomes. Reducing body weight through increased exercise and positive dietary habits have reduced insulin resistance and improved overall outcomes. Weight loss is associated with reductions in fasting plasma glucose and insulin levels, reductions in hepatic glucose outputs, peripheral insulin resistance, hypertension and dyslipidemia.(Blackburn, 1995, Eddy et al., 2005, Goldstein, 1992, Maggio and Pi-Sunyer, 1997)

Evidence for CHW/lay worker-related interventions for diabetes care

A Systematic Review(Shah et al., 2013) of the role of CHWs in diabetes care and management is summarized below.

Unique Contributions to Literature	**Source**	**Population and Setting**	**Study Design and Key Elements of Intervention**	**Outcomes**
community-based participatory research (CBPR) and description of behavioral theories of intervention	Spencer M; Rosland AM; et al.	164 African-American and Latino adults with type 2 diabetes in southwest and east Detroit, MI	6-month RCT to test effectiveness of a CBPR intervention for improving glycemic control.	Decrease in HBA1C from 8.6% at baseline to 7.8% at 6-month follow up and improved self-reported diabetes understanding
CBPR methods to deliver Diabetes Prevention Program(DPP) lifestyle intervention	Ruggiero L; Castillo A; et al.	3 large Latino populations in southwest Chicago at risk of type 2 diabetes	12-month non-randomized prospective study of a DPP, community-based intervention	Improved physical activity and dietary scores and improved BMI (< .91 kg/m2) and waist circumference (<1.56 in.) at 6 months
Community-based study solely utilizing CHWs with dietitian oversight	Katula JA: Vitolins MZ; et al.	Sample in Forsyth County, NC with fasting glucose from 95–125 mg/dL, and a BMI ≥25 and ≤39.9 kg/m2	24-month RCT testing a CHW-led weight loss intervention based on the Diabetes Prevention Program	Improved fasting glucoses (−4.3 vs −0.4 mg/dL) and weight loss (−7.1 vs 1.4kg) compared to control
Examination of long-term cost-effectiveness of CHW intervention using QALYs	Brown HS; Wilson KJ; et al.	46 low-income Hispanic adults from Laredo, Texas with type 2 diabetes	18-month non-randomized study of cost-effectiveness of CHW-led lifestyle intervention	Cost-effective ($33,319/QALY gained) based on the conventional $50,000 cutoff per QALY in patients with diabetes
Successful implementation of CHWs into team-based care model	Hargraves JL; Ferguson WJ; et al.	1415 patients from 12 community health centers in MA (494 patient from 6 centers in intervention)	24-month RCT incorporating CHWs into health care teams	Intervention group was more likely to set self-management goals
Team-based chronic care management incorporating CHWs	Allen JK; Dennison-Himmelfarb CR; et al.	525 patients with CVD or type 2 diabetes from 2 community health	12-month RCT using NP-CHW integrated team model for CVD risk reduction	Significant improvement in total cholesterol (difference, −19.7 mg/dL), LDL-C (−15.9 mg/dL), triglycerides (−16.3mg/dL), systolic blood pressure (−6.2 mmHg),

Unique Contributions to Literature	Source	Population and Setting	Study Design and Key Elements of Intervention	Outcomes
		centers in Baltimore, MD.		HbA1c (−0.5%) and perception of quality of care
Team-based approach that also provided detailed description of recruitment and training	Walton JW; Snead CA; et al.	100 uninsured or underinsured adult patients with type 2 diabetes from 5 charity clinics at Baylor Health Care System in Dallas TX.	5-year non-randomized study using CHWs supported by nurse care managers to provide diabetes self-management education	18-month results showed improved HbA1c (8.7% to 7.4%) and high levels of satisfaction with the program
Description of a diabetes self-management CHW certificate course	Ferguson WJ; Lemay CA; et al.	10 CHWs from 6 community health centers in MA (part of Hargraves et. al study above)	Non-randomized study of 2-day certificate course with follow-up trainings for CHWs	Improved knowledge and skills in diabetes self-management, and recommendations for CHW training programs
Development of an onsite and video-conference based training program	Colleran K, Harding E; et al.	23 diverse CHWs from across New Mexico	Non-randomized study training program for CHWs	New knowledge, skills and confidence for participants. The distance learning strategy allowed for extended training of a diverse group of participants
Study of CHWs by role (educator-only or educator + bridge)	Ayala GX; Vaz L; et al.	61 CHW programs in Latino communities	Systematic review of the roles of CHWs in Latino communities	Educator-only programs reached more participants and employed nearly all CHWs as staff; increased contact in educator + bridge.
Consensus on CHW scope of practice between CHWs and employers	Findley SE; Matos S; et al.	226 CHWs and 44 employers from New York	Non-randomized study surveying CHWs and employers on the CHW scope of practice	Nearly all CHWs willing to complete additional training; 93% of employers agreed standardized training would improve effectiveness; 5 roles identified for CHWs

Behaviour modification and diabetes control

A literature review(Jacobs-van der Bruggen et al., 2009) examining the impact of randomized controlled trials of patient-centered interventions focusing on lifestyle activities for type 2 diabetic patients simulated the long-term outcomes for these interventions on the Dutch diabetic population using a computer-based model.

Study findings demonstrated that the lifestyle interventions projected a reduction in lifetime cumulative incidence of cardiovascular complications by up to 6%. (Life-years gained per participant: 0.34 & Quality adjusted Life years (QALYs) gained per participant: 0.14).

Loss to follow up

In another prospective RCT (Babamoto et al., 2009) conducted in the United States among Hispanic populations in the inner city to determine the effectiveness of CHW led interventions in comparison to usual clinic practice found significantly greater proportions of patients enrolled in the standard provider care group (50%) and the case management group (43%) were lost to follow-up, as compared with the CHW group (28%)

Cost-effectiveness

The University of Texas Community Outreach (UTCO) intervention(Brown et al., 2012) is a community-based diabetes education and self-management programme that includes home-based CHW visits, classroom health education classes, nutrition classes, exercise classes, and counseling sessions.

This study followed a cohort of participants whose A1c levels were above 7% at baseline, but fell to 7% or below during the course of the 18-month intervention

The study used real-world cost structure and assumed ongoing annual costs at the 50% level.

- Using the Archimedes model, the UTCO intervention is expected to reduce the risk of a myocardial infarction by 2.6%, foot ulcers by 5.6%, and foot amputation by 3.5%.
- A1c levels will fall by 11.7%, and 413.52 life years will be gained through the intervention over a 20-year period among the 30 participants
- After accounting for health disutility weights, the UTCO intervention results in an incremental gain of 394.92 QALYs amongst 30 participants
- The resultant ICER for a 20-year period was $33,319 per QALY gained for the entire population relative to standard care
- The intervention was most cost-effective for those aged 50 to 65 years, with a ratio of $30,786 per QALY gained.
- The intervention had an ICER of $130,272 per QALY gained over a 5-year period and $56,009 per QALY gained over a 10-year period.
- Raising the effectiveness to 73% lowered the ICER to $28,093 per QALY gained.
- Adjusting the discount rate to 0% and to 6% resulted in ICERs per QALY gained of $30,026 and $37,473, respectively.
- Lowering annual costs from 50% of program costs to 25% resulted in an ICER of $21,977 per QALY gained; increasing them to 75% resulted in $45,696 per QALY gained.
- Eighty percent of the cohort that entered the program with an A1c level above 9% lowered their A1c levels to below 9% at follow-up. For this cohort, the ICER was $10,995 per QALY gained. This is largely a function of the long-term health care cost savings accrued.
- Decreasing effectiveness to 60% raised the ICER to $18,680 per QALY gained; raising effectiveness to 100% lowered it to $6,384 per QALY gained.
- Setting the discount rate for costs as well as QALYs gained to 0% lowered the ICER to $9,980 per QALY gained, and setting it at 6% raised the ICER to $12,405 per QALY gained.

- Finally, lowering continuance costs to 25% lowered the ICER to $2,156 per QALY gained; raising these costs to 75% resulted in an ICER of $19,834 per QALY gained.

Hospitalisation due to diabetes

A study in five states of America (Jiang et al., 2003) reported that 6.1% of all admissions were for acute diabetic complications, 25.1% had chronic diabetes complications and 91.7% had major cardiovascular diseases including hypertension, in 76.6% of patients.

In another study conducted in California (Kim et al., 2010), 10 56.7% of all patients with unscheduled admissions and 57.1% of scheduled admissions were for diabetes complications or for conditions other than the diabetes itself.

Umpierrez et.al (Umpierrez et al., 2002) reviewed 1886 admissions in the United States for the presence of hyperglycaemia (fasting glucose ≥7 mmol/l or random ≥11.1 mmol/l on two or more occasions) in surgery and general medicine patients. Of the patients admitted to hospital 26% were known to have diabetes and an additional 12% previously undiagnosed with diabetes had hyperglycaemia first detected in hospital. After adjusting for confounders the group with newly diagnosed hyperglycaemia had an 18-fold increase in in-hospital mortality. Patients with known diabetes had a 2.7-fold increase in comparison with normoglycaemic patients.

In a study conducted in the United Kingdom(Masson EA, 1992) 8.4% of all hospitalized patients were suffering from diabetes. Of all the diabetic patients, 14.5% died during that admission and 10.1% died of macro-vascular disease.

Diabetic patients are more prone to be admitted to hospital and it is a frequent co-morbid condition in hospitalized patients. The relative risk for hospital admission for diabetic patients is 2.97 and for people with both diabetes and hypertension the risk is 3.44 in comparison with patients without these risk factors.(Natarajan S, 2004) Diabetes also contributed significantly to prolonged hospital stay, as well as inpatient mortality. The median length of hospital stay was 22 days, significantly longer than 10 days for non-diabetic patients.(Masson EA, 1992)

Diabetes is frequently not diagnosed before admission, in addition to the fact that even after admission a significant proportion of patients will not have been recognized as having hyperglycaemia. Levetan et.al(Levitan CS, 1998) report a prevalence of laboratory documented hyperglycaemia in 13% of hospitalized patients; of these 64% had pre-existing hyperglycaemia or new onset diabetes. Thirty six percent of these remained unrecognized as having diabetes in an audit of discharge summaries.

An Australian study(Comino et al., 2015) to determine the risk factors for all-cause hospitalisation and excess risk due to diabetes in a large sample of older Australians found that patients with diabetes were more likely to have a hospitalisation than participants without diabetes (24.2%; aRR: 1.24, 95% CI: 1.21, 1.26).

The age-adjusted admission rates for all-cause hospitalisation for participants with and without diabetes were 631.3 and 454.8 per 1,000 participant year respectively. The mean number of hospital days among participants with diabetes was 8.3 vs. 5.5.

While self-reported Emergency Department (ED) admissions did not change significantly in the CHW and case management groups, they increased significantly from 13% to 28% ($p < .05$) in the standard provider care group(67% to 50%, $p < .05$). Patients who reported exercising at least 3 days a week increased from 28% to 63% ($p < .05$) in the CHW group and from 17% to 35% ($p < .05$) in the standard provider care group but remained unchanged in the case management group. Mean A1c decreased from 8.6% to 7.2% ($p < .05$) in the CHW group, 8.5% to 7.4% ($p < .05$) in the case management group, and 9.5% to 7.4% ($p < .05$) in the standard provider care group.

Table 2. Changes in Clinical Indicators and Self-Reported Health Measures by Study Group

	Community Health Worker ($n = 75$)		Case Management ($n = 60$)		Standard Provider Care ($n = 54$)	
Clinical Indicator	Baseline *n* (%)	6-Month Follow-Up *n* (%)	Baseline *n* (%)	6-Month Follow-Up *n* (%)	Baseline *n* (%)	6-Month Follow-Up *n* (%)
Good health in the previous 4 weeks[a]	4 (5)	43 (57)*	5 (8)	12 (20)	4 (7)	12 (22)
Admitted to emergency department in the previous 6 months†	15 (20)	7 (9)	9 (15)	12 (20)	7 (13)	15 (28)*
Never forgetting to take their diabetes medication†	52 (69)	59 (79)	46 (77)	33 (55)*	36 (67)	27 (50)*
Two or more servings of fresh fruit per day†	35 (47)	55 (73)*	30 (50)	47 (78)*	28 (52)	29 (54)
Two or more servings of fresh vegetables per day†	29 (39)	57 (76)*	19 (32)	34 (57)*	19 (35)	23 (43)
Two or more servings of fatty foods per day	22 (29)	12 (16)*	15 (25)	14 (23)	22 (41)	17 (32)
Exercise at least three times per week†	21 (28)	47 (63)*	15 (25)	23 (38)	9 (17)	19 (35)*
Mean Diabetes Knowledge Scale score†	10.6	14.7*	10.6	11.0	10.3	10.6
Mean A1c (%)[a]	8.6	7.2*	8.5	7.4*	9.5	7.4*
Mean body mass index (kg/m^2)[b]	32.5	32.0	32.2	32.5	31.2	31.5

a. Community health worker group, $n = 56$; case management group, $n = 48$; standard provider care group, $n = 43$.
b. Community health worker group, $n = 58$; case management group, $n = 37$; standard provider care group, $n = 31$.
†$p < .05$ between groups at 6-month follow-up. *$p < .05$ within groups at 6-month follow-up.

A cross-sectional retrospective audit(Ncube-Zulu, 2013) of medical records of all patients discharged from Chris Hani Baragwanath Academic Hospital in 2009 found that the total hospitalization costs per patient were significantly higher for diabetic patients; R27 216-06 ± R19 476-65 compared to R18 185-05 ± R16 725-90 for the non-diabetic patients. Furthermore, the average length of stay for diabetic patients was longer; 13.04 ± 9.29 days vs. 8.86 ± 8.33 days for non-diabetic patients. Average admission rate per patient per year was higher in diabetic patients 1.8 ± 0.8 times vs. 1.5 ± 0.6 times in non-diabetic patients. From the study sample 38.08 % of patients were patients diabetic.

A study drawing on discharge data for five states(Jiang et al., 2003) (California, Missouri, New York, Tennessee, and Virginia) in 1999 found that, among patients with diabetes who had been hospitalized, 30% had two or more stays accounting for 50% of total hospitalizations and hospital costs. The prevalence of diabetes complications and multiple conditions differed by age, race/ethnicity, and payer among patients with multiple stays.

A retrospective population-based cohort study(Khalid et al., 2014) in England of patients with T2D from January 2006 to December 2010 found approximately 60% had at least one hospitalisation during the 4-year study period. Rates of hospitalisation were as follows: all-cause, 33.9 per 100 patient-years (pt-yrs); non-diabetes-related, 29.1 per 100 pt-yrs; diabetes-related, 18.8 per 100 pt-yrs and hypoglycaemia, 0.3 per 100 pt-yrs. The risk of all-cause hospitalisation increased with hospitalisation in the previous year, insulin use and the presence of major comorbidities. The risk of a diabetes-related hospitalisation increased with age, female gender, insulin use, chronic renal insufficiency, hypoglycaemia (as diagnosed by a general practitioner) and diabetes-related hospitalisation in the previous year.

A review of 34,239 patients with a pneumonia-related hospitalization and 342,390 population control subjects found that diabetes duration ≥10 years increased the risk of a pneumonia-related hospitalization (1.37 [1.28–1.47]). Compared with subjects without diabetes, the adjusted RR was 1.22 (1.14–1.30) for diabetic subjects whose A1C level was <7% and 1.60 (1.44–1.76) for diabetic subjects whose A1C level was ≥9%.(Pinchevsky et al., 2015)

Glycemic control

The limited available local data suggest that more than two thirds of type 2 diabetes patients in South Africa have a glycated haemoglobin (HbA1c) level above the generally recommended target of 7.5%(Amod A, 2012)

A meta-analysis of CHW interventions(Palmas et al., 2015) to improve glycemic control found that CHW interventions showed a modest reduction in A1c compared to usual care. A1c reduction was larger in studies with higher mean baseline A1

First Author	Mean (SD) A1c Reduction in Intervention Arm N	Mean (SD) A1c reduction in Control Arm N	Weight (%)	Standardized Mean Difference (95 % confidence interval)
Brown	0.89 (0.26) 126	0.07 (2.95) 126	9.7	0.40 (0.15, 0.65)
Gary	0.20 (1.70) 273	0.08 (1.93) 269	21.3	0.07 (−0.10, 0.23)
Allen	0.60 (2.30) 264	0.10 (1.80) 261	20.5	0.24 (0.07, 0.41)
Prezio	1.60 (2.24) 90	0.95 (2.31) 90	7.0	0.28 (−0.01, 0.58)
DePue	0.31 (1.68) 95	0.03 (1.50) 148	9.1	0.17 (−0.08, 0.44)
Rothschild	0.96 (2.07) 73	−0.12 (1.66) 71	5.4	0.57 (0.24, 0.90)
Perez-Escamilla	0.86 (1.89) 105	0.34 (2.42) 106	8.2	0.24 (−0.03, 0.51)
Tang	0.39 (0.89) 60	0.55 (1.60) 56	4.6	−0.12 (−0.56, 0.31)
Palmas	0.29 (1.70) 179	0.07 (1.58) 181	14.1	0.13 (−0.07, 0.34)

First Author	Mean (SD) A1c Reduction in Intervention Arm N	Mean (SD) A1c reduction in Control Arm N	Weight (%)	Standardized Mean Difference (95 % confidence interval)
Overall				0.21 (0.11, 0.32) Heterogeneity I^2 = 0.37

A cluster-randomised trial in 12 primary care clinics in Tshwane district(Webb et al.) found the mean age was 58 years and 80.5% had a body mass index (BMI) ≥25 kg/m^2. Sixty-eight percent of patients were female. Acceptable glycemic control and LDL-cholesterol were found for only 27% and 33% of patients, respectively (HbA1c < 7%; LDL < 2.5 mmol/l). Despite more than 79% of patients reporting to be hypertensive, 68% of patients had a systolic blood pressure above 130 mmHg and 64% had a diastolic blood pressure above 80 mmHg.

Using a public sector database, retrospective data on the treatment of type 2 diabetes mellitus(Yacob Pinchevsky, 2013) participants found the mean age of the patients was 63 years [standard deviation (SD) 11.9], 55% of whom were females. The HbA1c was 8.8% (SD 2.5). 26.2% of patients attained HbA1c levels of < 7%. Of the total patients, 45.8% met a < 130/80 mmHg blood pressure target, and 53.8% a low-density lipoprotein (LDL) cholesterol of < 2.5 mmol/l. Only 7.5% obtained the combined target for HbA1c, blood pressure and LDL cholesterol.

A 1% reduction in A1c levels has been correlated with a 21% reduction in vascular complications in people with diabetes, resulting in fewer complications and reduced lifetime health care costs. (Stratton et al., 2000a)Additionally, researchers have found that among the 2.1 million people in the United States with type 2 diabetes, those with good glycemic control (A1c 7 or less) had direct diabetes-related medical costs that were 16% lower than those with fair glycemic control (A1c ≥7 - ≤9) and 20% lower than those with poor glycemic control (A1c > 9).(Oglesby et al., 2006)

A study in the United States(Oglesby et al., 2006) to quantify the association between direct medical costs attributable to type 2 diabetes and level of glycemic control show that direct medical costs attributable to type 2 diabetes were 16% lower for individuals with good glycemic control than for those with fair control ($1,505 vs. $1,801, p < 0.05), and 20% lower for those with good glycemic control than for those with poor control ($1,505 vs. $1,871, p < 0.05). Prescription drug costs were also significantly lower for individuals with good glycemic control compared to those with fair ($377 vs. $465, p < 0.05) or poor control ($377 vs. $423, p < 0.05).

A retrospective cohort study(Blecker et al., 2016) of outpatients with heart failure and diabetes in New York City found that, compared to patients with an HbA1c of 8.0–8.9 %, patients with an HbA1c of <6.5, 6.5–6.9, 7.0–7.9, and ≥9.0 % had an adjusted hazard ratio (aHR) (95 % CI) for all-cause hospitalization of 1.03 (0.90–1.17), 1.05 (0.91–1.22), 1.03 (0.90–1.17), and 1.13 (1.00–1.28), respectively. An HbA1c ≥ 9.0 % was also associated with an increased risk of heart failure hospitalization (aHR 1.33; 95 % CI 1.11–1.59) and a non-significant increased risk in mortality (aHR 1.20; 95 % CI 0.99–1.45) when compared to HbA1c of 8.0–8.9 %.

Another study(Nichols et al., 2013) to evaluate the relationship between glycemic control and cardiovascular disease (CVD) hospitalizations and all-cause mortality among type 2 diabetes patients found that compared with patients with mean A1C 7.0%-7.4%, those with mean A1C <6.0% had a 75% increased risk of CVD hospitalization (hazard ratio [HR] 1.68, 95% CI 1.39-2.04, p<0.001) after adjustment for demographic and clinical characteristics. Those with A1C 6.0%-6.4% (1.18, 1.00-1.40, p=0.048) and 6.5%-6.9% (1.18, 1.02-1.37, p=0.031) also had significantly higher risk relative to the reference group of 7.0%-7.4%, as did patients with A1C 8.5%-8.9% (HR 1.55, 1.24-1.94, p<0.001) and >9.0% (HR 1.83, 1.50-2.22, p<0.001). Risk of all-cause mortality was significantly greater than the reference group among A1C categories <6.0%, 6.0%-6.4%, 6.5%-6.9%, and >9.0%.

A prospective study(Stratton et al., 2000b) from 23 hospital based clinics in England, Scotland and Ireland found that for every 1% reduction in mean HbA1c was associated with reductions in risk of 21% for any end point related to diabetes, 21% for deaths, 14% for myocardial infraction, and 37% for microvascular complications.

A study conducted in Italy(Esposti et al., 2013) to determine hospital costs related to glycemic control reported findings from other studies including Oglesby et al who found that diabetes-related costs were 16% and 20% lower for patients with good control (glycated hemoglobin [HbA_{1c}] ≤7%) compared with those having fair control (HbA_{1c} >7%–9%) and poor control (HbA_{1c} >9%), while Menzin et al reported that patients with a mean HbA_{1c} ≥10% had higher diabetes-related hospital costs than those with a mean HbA_{1c} <7%. The study found that over 2 years, the mean diabetes-related cost per person was: €1291.56 in patients with excellent control; €1545.99 in those with good control; €1584.07 in those with fair control; €1839.42 in those with poor control; and €1894.80 in those with very poor control. After adjustment, compared with the group having excellent control, the estimated excess cost per person associated with the groups with good control, fair control, poor control, and very poor control was €219.28, €264.65, €513.18, and €564.79, respectively.

A study conducted in the United States(Sokol et al., 2005) to evaluate the impact of medication adherence on healthcare utilization and cost for chronic conditions including diabetes and hypertension found:

Disease related cost for diabetes and hypercholesterolemia, high levels of medication adherence were associated with lower disease- related medical costs. Total healthcare costs decrease at high levels of medication adherence, despite the increased drug related costs.

Hospitalization risk for all 4 conditions, patients who maintained 80% to 100% medication adherence were significantly less likely to be hospitalized compared with patients with lower levels of adherence.

All-cause costs for diabetes, hypertension, and hypercholesterolemia, high levels of adherence with condition-specific drugs were associated with lower medical costs across all of the patients' treated conditions. For all 3 conditions, total healthcare costs decreased at high levels of drug adherence, despite the increased drug costs.

For diabetes and hypercholesterolemia, high levels of medication adherence are generally associated with a net economic benefit in disease-related costs. Higher drug costs are more than offset by reductions in medical costs, yielding a net reduction in overall healthcare costs. This pattern is observed at all adherence levels for diabetes and at most adherence levels for hypercholesterolemia. For hypertension, medical costs tended to be lowest at high levels of medication adherence, but offsets in total healthcare costs

were generally not found. The cost impacts of adherence may be less salient for condition hypertension, for which a large fraction of the treated population has a relatively low risk of near-term complication.

Condition	Adherence Level	N	Medical Cost ($)	Drug Cost ($)	Total Cost ($)	Hospitalization Risk (%)
Diabetes	1–19	182	8812*	55	8867	30*
	20–39	259	6959*	165	7124	26*
	40–59	419	6237*	285	6522	25*
	60–79	599	5887*	404	6291	20*
	80–100	1801	3808	763	4570	13
			$F = 36.62^{\dagger}$	**$F = 88.57^{\dagger}$**		**χ^2 (25 df) = 543.6†**
			Adj. $r^2 = 0.18$	**Adj. $r^2 = 0.36$**		
Hypertension	1–19	350	4847	31	4878	28*
	20–39	344	5973*	89	6062	24*
	40–59	562	5113	184	5297	24*
	60–79	921	4977	285	5262	20
	80–100	5804	4383	489	4871	19
			$F = 46.44^{\dagger}$	**$F = 171.98^{\dagger}$**		**χ^2 (31 df) = 1256.3†**
			Adj. $r^2 = 0.13$	**Adj. $r^2 = 0.37$**		

A retrospective cohort study conducted in the United States(Ho et al., 2006) to determine the association between medication no adherence and clinical outcomes found that medication no adherence was significantly associated with increased risks for all-cause hospitalization (odds ratio, 1.58; 95% confidence interval, 1.38-1.81; *P*<.001) and for all-cause mortality (odds ratio, 1.81; 95% confidence interval, 1.46-2.23; *P*<.001)

Incremental increases in medication adherence were associated with improved outcomes. Each 25% increase in adherence to antihypertensive medication was associated with −1.0 mm Hg (95% CI, −1.5 to −0.6 mm Hg) and −1.2 mm Hg (95% CI, −1.4 to −0.9 mm Hg) reductions in systolic and diastolic BPs, respectively. Similarly, each 25% increase in adherence to oral hypoglycemics and statins was associated with −0.05% (95% CI, −0.08% to −0.01%) and −3.8 mg/dL (−0.10 mmol/L) (95% CI, −4.5 to −3.0 mg/dL [−0.12 to −0.08 mmol/L]) reductions in HbA_{1c} and LDL-C levels, respectively. Furthermore, 25% increases in medication adherence were associated with significant reductions in all-cause hospitalization (OR, 0.83; 95% CI, 0.79-0.88; *P*<.01) and in all-cause mortality (OR, 0.75; 95% CI, 0.68-0.83; *P*<.01).

Table 5. Association Between Medication Nonadherence and Outcomes Using Different PDC Cutoffs*

PDC Cutoff, %	Summary Measure		Oral Hypoglycemics		Antihypertensives		Statins	
	Mortality	Hospitalization	Mortality	Hospitalization	Mortality	Hospitalization	Mortality	Hospitalization
<50	2.01 (1.38-2.94)	1.66 (1.34-2.04)	1.74 (1.17-2.59)	1.50 (1.22-1.86)	2.16 (1.46-2.80)	2.02 (1.46-2.80)	2.30 (1.49-3.56)	1.39 (1.09-1.78)
<60	2.02 (1.56-2.73)	1.66 (1.34-2.04)	1.56 (1.12-2.18)	1.60 (1.35-1.89)	2.07 (1.42-3.02)	1.56 (1.23-1.99)	2.45 (1.70-3.51)	1.28 (1.04-1.58)
<70	1.95 (1.53-2.48)	1.49 (1.26-1.77)	1.54 (1.16-2.06)	1.49 (1.29-1.73)	2.09 (1.56-2.81)	1.62 (1.35-1.94)	2.22 (1.60-3.10)	1.39 (1.16-1.67)
<80	1.81 (1.46-2.23)	1.58 (1.38-1.81)	1.39 (1.07-1.82)	1.38 (1.21-1.58)	1.58 (1.22-2.05)	1.44 (1.24-1.67)	2.07 (1.54-2.80)	1.39 (1.18-1.63)
<90	1.71 (1.42-2.07)	1.48 (1.32-1.66)	1.48 (1.16-1.89)	1.36 (1.20-1.54)	1.57 (1.25-1.98)	1.45 (1.27-1.65)	1.76 (1.34-2.32)	1.28 (1.11-1.47)
<100	1.47 (1.22-1.77)	1.35 (1.24-1.50)	1.49 (1.17-1.89)	1.44 (1.27-1.62)	1.34 (1.07-1.68)	1.38 (1.23-1.56)	1.40 (1.07-1.82)	1.27 (1.11-1.44)

A study conducted in the United States(Aikens and Piette, 2013) to determine whether self-reported medication adherence predicts future glycemic control in Type 2 diabetes found that only half of patients reported high adherence. The study found that even after adjusting for baseline HbA_{1c}, each one-point increase in baseline Morisky total score was associated with a 1.8 mmol/mol (or 0.16%) increase in

HbA_{1c}measured 6 months later. Additionally, baseline endorsement of forgetting to take medication was associated with a 4.7 mmol/mol (or 0.43%) increase in 6-month HbA_{1c} (*P* = 0.005).

Another cross-sectional survey of adults in Ethiopia(Kassahun et al., 2016) found that more than two-third (70.9 %) of the patients had poor blood glycemic control. Patients who were illiterate (AOR = 3.46, 95 % CI 1.01–11.91) and farmer (AOR = 2.47, 95 % CI 1.13–5.39) had high odds of poor glycemic control. In addition, taking combination of insulin and oral medication (AOR = 4.59, 95 % CI 1.05–20.14) and poor medication adherence (AOR = 5.08 95 % CI 2.02–12.79) associated statistically with poor glycemic control.

Mortality

A Swedish study(Tancredi et al., 2015) to determine the excess risk of mortality among diabetic patients found that the overall rate of death per 1000 person-years was 38.64 among persons with type 2 diabetes (77,117 deaths among 435,369 patients [17.7%]), as compared with 30.30 among controls (306,097 deaths among 2,117,483 controls [14.5%]). For cardiovascular mortality, the rate per 1000 person-years was 17.15 among patients with type 2 diabetes, as compared with 12.86 among controls. Among persons with type 2 diabetes with a time-updated mean glycated hemoglobin level of 6.9% or less (≤52 mmol per mole) and an age of less than 55 years, the excess risks of death were approximately twice as high as the risks among controls (hazard ratio for death from any cause, 1.92; 95% CI, 1.75 to 2.11; hazard ratio for cardiovascular death, 2.18; 95% CI, 1.81 to 2.64) Among patients in the highest category of glycated hemoglobin level (≥9.7% [≥83 mmol per mole]) who were younger than 55 years of age, the hazard ratio for death from any cause, as compared with controls, was 4.23 (95% CI, 3.56 to 5.02) and the hazard ratio for cardiovascular death was 5.38 (95% CI, 3.89 to 7.43). Among patients 75 years of age or older in this glycated-hemoglobin category, the corresponding hazard ratio for death from any cause was 1.55 (95% CI, 1.47 to 1.63) and the hazard ratio for cardiovascular death was 1.42 (95% CI, 1.32 to 1.53).

Diabetes Modelling

There is a prevalence of 3.5 million diabetics in South Africa and a yearly incidence of 148,053. 35% of diabetic are undiagnosed. Currently 30% of diagnosed diabetics have their diabetes under control. The year risk of hospitalisation is 22% higher for a controlled diabetic than non-diabetic (Pinchevsky et al., 2015) and the cost per hospitalisation is 39% higher for uncontrolled than controlled diabetics (Oglesby et al., 2006).

For the purpose of this investment case, we are calculating the cost impact of increased PHC visits and drugs for the additional diabetics diagnosed, combined with the averted hospitalisations of higher case finding and higher control rate due to CHWs interventions. We calculate the net cost of CHW intervention by adding the cost of CHWs for the share of their time spent on diabetic case finding and control.

We assumed conservatively, based on the literature review above, that the diagnosis rate will increase by 7% due to systematic screening by CHWs and that the rate of controlled diabetes increases by 7%. Controlled diabetes adds 6.9 years to life expectancy compared to uncontrolled (Tancredi et al., 2015). With a disability weight of 0.133 (Salomon et al.), and a 3% discount rate, 1,195,112 DALYs would be averted over 10 years with the increased number of controlled patients in the CHW scenario. The cost

per DALY averted would amount to R6,096 or 8% of the GDP per capita. WHO estimates that an intervention is highly cost-effective if the cost per DALYs averted is equal or inferior to the GDP per capita. CHWs intervention for diabetes is a highly cost-effective intervention.

Year 1 reflects 1st year of a fully operational high performing CHW team

Table 9. Modelling of diabetic costs with CHW scenario

Diabetic costs in Rds 2017	Standard	Scenario
	Yr 1	Yr 1
Prevalence	3,500,000	3,500,000
% diagnosed	65%	72%
Prevalence on treatment	2,280,000	2,520,000
Additional diabetic on treatment		240,000
% controlled	30%	37%
Controlled	684,000	932,400
Additional controlled		248,400
Number PHC visits per additional diagnosed patients Yr 1		12
Hospitalisation rate		
Risk Hospitalisation non-diabetic/year	0.10	0.10
Risk Hospitalisation diabetic controlled/year	0.12	0.12
Risk Hospitalisation diabetic uncontrolled	0.20	0.20
Cost per hospitalisation Rds 2017		
diabetic controlled	26,553	26,553
diabetic uncontrolled	33,191	33,191
Number controlled	684,000	932,400
Number uncontrolled	1,596,000	1,587,600
Cost of PHC visits for additional diabteics on treatment		R 1,138,780,171
Hospitalisation costs	12,561,972,224	R 13,272,595,908
Savings on hospitalisation		-R 710,623,684
Time CHWs on Diabetes		10.00%
CHWs cost		R 884,770,394
Combined costs and savings CHWs		R 1,312,926,881

Share of CHW time on diabetes	10%
DALYs averted	1.2 million over 10 years
Cost per DALY averted	R6,096

References

AIKENS, J. E. & PIETTE, J. D. 2013. Longitudinal association between medication adherence and glycaemic control in Type 2 diabetes. *Diabetic medicine : a journal of the British Diabetic Association,* 30**,** 338-344.

AMOD A, A.-E. B., BERG GI, BLOM DJ, BROWN SL, CARRIHILL MM, DAVE JA, DISTILLER LA, GANIE YN, GROBLER N, HEILBRUNN AG, HUDDLE KRL, JANSE VAN RENSBURG G, JIVAN D, JOSHI P, KHUTSOANE DT, LEVITT NS, MAY WM, MOLLENTZE WF, MOTALA AA, PARUK IM, PIRIE FJ, RAAL FJ, RAUFF S, RAUBENHEIMER PJ, RANDEREE HAR, RHEEDER P,TUDHOPE L, VAN ZYL DJ, YOUNG M; GUIDELINE COMMITTEE. 2012. The 2012 SEMDSA Guideline for the Management of Type 2 Diabetes (Revised). *JEMDSA* 17**,** S1-S95.

BABAMOTO, K. S., SEY, K. A., CAMILLERI, A. J., KARLAN, V. J., CATALASAN, J. & MORISKY, D. E. 2009. Improving diabetes care and health measures among hispanics using community health workers: results from a randomized controlled trial. *Health Educ Behav,* 36**,** 113-26.

BLACKBURN, G. 1995. Effect of degree of weight loss on health benefits. *Obes Res,* 3 Suppl 2**,** 211s-216s.

BLECKER, S., PARK, H. & KATZ, S. D. 2016. Association of HbA1c with hospitalization and mortality among patients with heart failure and diabetes. *BMC Cardiovascular Disorders,* 16**,** 99.

BROWN, H. S., 3RD, WILSON, K. J., PAGAN, J. A., ARCARI, C. M., MARTINEZ, M., SMITH, K. & REININGER, B. 2012. Cost-effectiveness analysis of a community health worker intervention for low-income Hispanic adults with diabetes. *Prev Chronic Dis,* 9**,** E140.

COMINO, E. J., HARRIS, M. F., ISLAM, M. D. F., TRAN, D. T., JALALUDIN, B., JORM, L., FLACK, J. & HAAS, M. 2015. Impact of diabetes on hospital admission and length of stay among a general population aged 45 year or more: a record linkage study. *BMC Health Services Research,* 15**,** 12.

DIABETES PREVENTION PROGRAM RESEARCH, G. 2002. REDUCTION IN THE INCIDENCE OF TYPE 2 DIABETES WITH LIFESTYLE INTERVENTION OR METFORMIN. *The New England journal of medicine,* 346**,** 393-403.

EDDY, D. M., SCHLESSINGER, L. & KAHN, R. 2005. Clinical outcomes and cost-effectiveness of strategies for managing people at high risk for diabetes. *Ann Intern Med,* 143**,** 251-64.

ESPOSTI, L. D., SARAGONI, S., BUDA, S., STURANI, A. & ESPOSTI, E. D. 2013. Glycemic control and diabetes-related health care costs in type 2 diabetes; retrospective analysis based on clinical and administrative databases. *ClinicoEconomics and Outcomes Research: CEOR,* 5**,** 193-201.

FABER M, K. H. 2005. Dietary intake, perceptions regarding body weight, and attitudes toward weight control of normal weight, overweight, and obese Black females in a rural village in South Africa. *Ethn Dis.,* 15**,** 238-245.

FEDERATION, I. D. 2015. *South Africa* [Online]. Available: https://www.idf.org/our-network/regions-members/africa/members/25-South Africa.

GAZIANO, T. A., ABRAHAMS-GESSEL, S., DENMAN, C. A., MONTANO, C. M., KHANAM, M., PUOANE, T. & LEVITT, N. S. 2015. An assessment of community health workers' ability to screen for cardiovascular disease risk with a simple, non-invasive risk assessment instrument in Bangladesh, Guatemala, Mexico, and South Africa: an observational study. *Lancet Glob Health,* 3**,** e556-63.

GAZIANO, T. A., BERTRAM, M., TOLLMAN, S. M. & HOFMAN, K. J. 2014. Hypertension education and adherence in South Africa: a cost-effectiveness analysis of community health workers. *BMC Public Health,* 14**,** 240.

GOLDSTEIN, D. J. 1992. Beneficial health effects of modest weight loss. *Int J Obes Relat Metab Disord,* 16**,** 397-415.

HARRIES, A. D., LIN, Y., SATYANARAYANA, S., LONNROTH, K., LI, L., WILSON, N., CHAUHAN, L. S., ZACHARIAH, R., BAKER, M. A., JEON, C. Y., MURRAY, M. B., MAHER, D., BYGBJERG, I. C., ENARSON,

D. A., BILLO, N. E. & KAPUR, A. 2011. The looming epidemic of diabetes-associated tuberculosis: learning lessons from HIV-associated tuberculosis. *Int J Tuberc Lung Dis,* 15**,** 1436-44, i.

HEALTH, D. O. 2016. SADHS South Africa Demographic and Health Survey 2016. Key Indicator Report. Stats SA.

HO, P., RUMSFELD, J. S., MASOUDI, F. A. & ET AL. 2006. Effect of medication nonadherence on hospitalization and mortality among patients with diabetes mellitus. *Archives of Internal Medicine,* 166**,** 1836-1841.

JACOBS-VAN DER BRUGGEN, M. A., VAN BAAL, P. H., HOOGENVEEN, R. T., FEENSTRA, T. L., BRIGGS, A. H., LAWSON, K., FESKENS, E. J. & BAAN, C. A. 2009. Cost-effectiveness of lifestyle modification in diabetic patients. *Diabetes Care,* 32**,** 1453-8.

JIANG, H. J., STRYER, D., FRIEDMAN, B. & ANDREWS, R. 2003. Multiple hospitalizations for patients with diabetes. *Diabetes Care,* 26**,** 1421-6.

KASSAHUN, T., ESHETIE, T. & GESESEW, H. 2016. Factors associated with glycemic control among adult patients with type 2 diabetes mellitus: a cross-sectional survey in Ethiopia. *BMC Research Notes,* 9**,** 78.

KHALID, J. M., RALUY-CALLADO, M., CURTIS, B. H., BOYE, K. S., MAGUIRE, A. & REANEY, M. 2014. Rates and risk of hospitalisation among patients with type 2 diabetes: retrospective cohort study using the UK General Practice Research Database linked to English Hospital Episode Statistics. *International Journal of Clinical Practice,* 68**,** 40-48.

KIM, H., ROSS, J. S., MELKUS, G. D., ZHAO, Z. & BOOCKVAR, K. 2010. Scheduled and unscheduled hospital readmissions among patients with diabetes. *Am J Manag Care,* 16**,** 760-7.

KRUGER HS, P. T., SENEKAL M, VAN DER MERWE MT. 2005. Obesity in South Africa: challenges for government and health professionals. *Public Health Nutr,* 8**,** 491-500.

LEVITAN CS, P. M., JABLONSKI K, KASS M, RATNER RE. 1998. Unrecognized diabetes among hospitalized patients. *Diabetes Care 1998,* 21**,** 246-249.

MAGGIO, C. A. & PI-SUNYER, F. X. 1997. The prevention and treatment of obesity. Application to type 2 diabetes. *Diabetes Care,* 20**,** 1744-66.

MASSON EA, M. I., POWER E, WALLYMAHMED M. 1992. An audit of the management and outcome of hospital inpatients with diabetes:Resource planning implications for the diabetes care team. *Diabetic Med,* 9.

MASSYN N, P. N., ENGLISH R, PADARATH A, BARRON P, DAY C, EDITORS 2016. District Health Barometer 2015/2016. Durban: Health Systems Trust.

MUHAMMAD ASHIQUE HAIDER CHOWDHURY, A. T. S., SHYFUDDIN AHMED, DEWAN SHAMSUL ALAM 2016. Effect of community health worker-provided targeted education with regular follow-up of hypertensive patients on blood pressure control: 24-month results of a longitudinal study in Bangladesh. *International Journal of Non Communicable Diseases,* 1 105-115.

NATARAJAN S, N. P. 2004. Hypertension, diabetes, hypercholesterolemia and their combinations increased health care utilization and decreased health status. *J Clin Epidemiol* 57**,** 954-961.

NCUBE-ZULU, T. 2013. Hospitalisation rates, length and cost of hospitalisation of diabetic and non-diabetic patients in a tertiary hospital in Johannesburg. . *Diss*.

NDOU, T., VAN ZYL, G., HLAHANE, S. & GOUDGE, J. 2013. A rapid assessment of a community health worker pilot programme to improve the management of hypertension and diabetes in Emfuleni sub-district of Gauteng Province, South Africa. *Global Health Action,* 6**,** 10.3402/gha.v6i0.19228.

NICHOLS, G. A., JOSHUA-GOTLIB, S. & PARASURAMAN, S. 2013. Glycemic control and risk of cardiovascular disease hospitalization and all-cause mortality. *J Am Coll Cardiol,* 62**,** 121-7.

OGLESBY, A. K., SECNIK, K., BARRON, J., AL-ZAKWANI, I. & LAGE, M. J. 2006. The association between diabetes related medical costs and glycemic control: A retrospective analysis. *Cost Effectiveness and Resource Allocation,* 4**,** 1-1.

OTTERMANN, B. 2010. Diabetes, TB and HIV/Aids. *Health 24*.

PALMAS, W., MARCH, D., DARAKJY, S., FINDLEY, S. E., TERESI, J., CARRASQUILLO, O. & LUCHSINGER, J. A. 2015. Community Health Worker Interventions to Improve Glycemic Control in People with Diabetes: A Systematic Review and Meta-Analysis. *Journal of General Internal Medicine,* 30**,** 1004-1012.

PAUL RHEEDER, T. M., STEFAN LAWSON & JULIE BRINK 2016. Diabetes and hypertension screening in Zandspruit, Johannesburg 2012–2014. *South African Family Practice* 58**,** 219-224.

PERREAULT, S., DORAIS, M., COUPAL, L., PARADIS, G., JOFFRES, M. R. & GROVER, S. A. 1999. Impact of treating hyperlipidemia or hypertension to reduce the risk of death from coronary artery disease. *CMAJ: Canadian Medical Association Journal,* 160**,** 1449-1455.

PINCHEVSKY, Y., BUTKOW, N., CHIRWA, T. & RAAL, F. J. 2015. Glycaemic, blood pressure and cholesterol control in 25 629 diabetics. *Cardiovascular Journal of Africa,* 26**,** 188-192.

PUOANE T, S. K., BRADSHAW D, . 2002. Obesity in South Africa: the South African demographic and health survey. . *Obes Res,* 10**,** 1038-1048.

SALOMON, J. A., HAAGSMA, J. A., DAVIS, A., DE NOORDHOUT, C. M., POLINDER, S., HAVELAAR, A. H., CASSINI, A., DEVLEESSCHAUWER, B., KRETZSCHMAR, M., SPEYBROECK, N., MURRAY, C. J. L. & VOS, T. Disability weights for the Global Burden of Disease 2013 study. *The Lancet Global Health,* 3**,** e712-e723.

SCHUTTE, K. S. A. A. 2013. *EPIDEMIOLOGY OF HYPERTENSION IN SOUTHERN AFRICA* [Online]. Available: https://www.saheart.org/cms-home/viewFile/53.

SHAH, M., KASELITZ, E. & HEISLER, M. 2013. The Role of Community Health Workers in Diabetes: Update on Current Literature. *Current diabetes reports,* 13**,** 163-171.

SOKOL, M. C., MCGUIGAN, K. A., VERBRUGGE, R. R. & EPSTEIN, R. S. 2005. Impact of Medication Adherence on Hospitalization Risk and Healthcare Cost. *Medical Care,* 43**,** 521-530.

STEYN K, L. N. 2006. Health Services Research in South Africa for Chronic Diseases of Lifestyle *Chronic Diseases of Lifestyle in South Africa 1995-2005.* South African Medical Research Council.

STRATTON, I. M., ADLER, A. I., NEIL, H. A. W., MATTHEWS, D. R., MANLEY, S. E., CULL, C. A., HADDEN, D., TURNER, R. C. & HOLMAN, R. R. 2000a. Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. *BMJ : British Medical Journal,* 321**,** 405-412.

STRATTON, I. M., ADLER, A. I., NEIL, H. A. W., MATTHEWS, D. R., MANLEY, S. E., CULL, C. A., HADDEN, D., TURNER, R. C. & HOLMAN, R. R. 2000b. Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. *BMJ,* 321**,** 405-412.

TANCREDI, M., ROSENGREN, A., SVENSSON, A.-M., KOSIBOROD, M., PIVODIC, A., GUDBJÖRNSDOTTIR, S., WEDEL, H., CLEMENTS, M., DAHLQVIST, S. & LIND, M. 2015. Excess Mortality among Persons with Type 2 Diabetes. *New England Journal of Medicine,* 373**,** 1720-1732.

UMPIERREZ, G. E., ISAACS, S. D., BAZARGAN, N., YOU, X., THALER, L. M. & KITABCHI, A. E. 2002. Hyperglycemia: an independent marker of in-hospital mortality in patients with undiagnosed diabetes. *J Clin Endocrinol Metab,* 87**,** 978-82.

WEBB, E. M., RHEEDER, P. & VAN ZYL, D. G. Diabetes care and complications in primary care in the Tshwane district of South Africa. *Primary Care Diabetes,* 9**,** 147-154.

YACOB PINCHEVSKY, N. B., FREDERICK J RAAL, TOBIAS CHIRWA 2013. The implementation of guidelines in a South African population with type 2 diabetes. *JEMDSA,* 18.

Palliative Care

There is an increasing recognition of the need for palliative care. A multi-country study conducted in Africa (Tanzania, Botswana, Ethiopia, Uganda and Zimbabwe) found the proportion of people requiring palliative care to be at least 0.5 - 1% of the total population.(World Health Organization). A Community Health Approach to Palliative Care for HIV/AIDS and Cancer Patients in Sub-Saharan Africa. Geneva: WHO, 2005]. Beyond cancer and AIDs patients, the increasing number of patients with terminal non-communicable disease requires an increase in palliative care. It is estimated that there will be a 300% increase in requirement for palliative care in such patients over the next 20 years. In a study of hospital in-patients in the Cape metropole, van Niekerk and Raubenheimer found that 1 in 6 (16.7%) of adult inpatients required palliative care.(Raubenheimer, 2014)

Significant cost savings from hospital-based palliative care consultation teams have been demonstrated, but even more savings are estimated to be achievable by providing patients with the necessary support to die at home

CHWs, alongside doctors, can play an important role in the delivery of palliative care. Ntizimira & al explain how CHWs identified patients in need of palliative care then send the information to the district palliative care team for mapping. They add that anecdotal data indicates a high level of satisfaction by patients and family members with palliative care assisted at community level.(Ntizimira et al., 2015)

In a study on HIV/AIDS patients, Uys (Uys, 2002) stated that CHWs are uniquely positioned to improve end-of-life care for historically marginalized communities. The range of care ranged from personal care (bathing, meal preparation, ambulation, bed baths, and mouth and wound care) to administering multivitamins and food supplements.

The most common kind of assistance given was counselling and information (94%). Symptom control also featured very often (69% of clients). The relatively lower percentages of clients who required physical care (hygiene and wounds) may be due to the fact that only 19% of the clients were bedridden, while 43% were relatively symptom free. The majority of clients received between two and four visits a month (53%) but about 20% received seven or more visits per month. Uys adds that it might appear that symptom-free clients get too many visits, but they are often in need of much counselling, teaching and welfare assistance.

In a cost analysis conducted to evaluate the hospital-based and outreach palliative care programme (Baragwanath Academic Hospital, Johannesburg) Hongoro and Dinat (Hongoro and Dinat, 2011) found that the cost per outreach visit was 50% less than the average cost of a patient day equivalent for district hospitals.

In a study on length of stay in hospital for palliative care patients, Starks & al found that 86% of patients stayed under 1 month. (Starks et al., 2013)

Palliative Modelling

The purpose of this modelling is to estimate the savings for the health system of home-based care for palliative patients as opposed to hospital stay for those patients who can be managed at home. We

compare 2 weeks in palliative care in hospital with 2 weeks palliative care at home if half of the patients currently in hospital for palliative care were managed at home.

On the basis of the literature review above we made the following assumptions:

- 0.75% of uninsured population require palliative care
- 50% are currently managed in hospitals
- 50% of those will be managed at home
- CHWs will be performing palliative care alongside PNs
- The average length of stay in hospital is 15 days
- The cost per Patient Day Equivalent (PDE) is equal to the average cost at district hospital and regional hospital. The cost per PDE would stand at R2,820.
- In parallel with an average length of stay of 2 weeks, we assumed that patients managed at home would have 1 outreach doctor visit.
- The cost of an outreach visit is R1,338 by a doctor, half the cost of a PDE in a district hospital
- Each patient will also be visited an average of 3 times a week by a professional nurse for administration of morphine (this is an average as not all patients will require injectable morphine)
- Besides the cost of the outreach visits, the cost of CHWs will reflect the cost of 4 home visits a week (8 home visits for the 2 weeks)
- No deaths or DALYs will be averted

If 50% of patients currently managed in hospital for palliative care were moved to home management for an average of 2 weeks, the cost of home management would stand at R330.7 million a year, whilst it would have been R3.7 billion if they had been managed in hospital, a saving of R3.3 billion a year. Over 10 years the savings would amount to R29 billion.

Table 10. Palliative care modelling

	Year 1	10 years
Proportion pop needing palliative	0.75%	
Pop uninsured needing palliative	348,033	
% hospitalised	50%	
% moved to home-based palliative	50%	
# hospital palliative averted	87,008	
Average length of stay hosp	15	
Cost per PDE	R 2,820	
Cost hosp stays	R 3,680,448,975	
Cost per Dr outreach visit	R 1,338	
# PN visits per patient	6	
Cost PN visits	243,531,430	
# CHW visits per patient	8	
Cost CHWs	R 87,241,073	
Costs Dr+PN+CHWs	R 330,773,840	
Savings hospital palliative averted	R 3,349,675,135	R 29,318,129,105

References

HONGORO, C. & DINAT, N. 2011. A cost analysis of a hospital-based palliative care outreach program: implications for expanding public sector palliative care in South Africa. *J Pain Symptom Manage,* 41**,** 1015-24.

NTIZIMIRA, C., SEBATUNZI, O., MUKESHIMANA, O., UMUTESI, V. & NGIZWENAYO, S. 2015. OA55 Impact of community health workers for continuum care of palliative care at community level integrated in rwanda public health system. *BMJ Support Palliat Care,* 5 Suppl 1**,** A17.

RAUBENHEIMER, L. V. N. A. P. J. 2014. A point-prevalence survey of public hospital inpatients with palliative care needs in Cape Town, South Africa. *S Afr Med J*.

STARKS, H., WANG, S., FARBER, S., OWENS, D. A. & CURTIS, J. R. 2013. Cost Savings Vary by Length of Stay for Inpatients Receiving Palliative Care Consultation Services. *Journal of Palliative Medicine,* 16**,** 1215-1220.

UYS, L. R. 2002. The practice of community caregivers in a home-based HIV/AIDS project in South Africa. *J Clin Nurs,* 11**,** 99-108.

BENEFITS FOR THE ECONOMY AND SOCIETY

Estimating the multiplier of a current injection of CHW expenditure

The multiplier is an estimate of the extent to which an "injection" into the economy through additional government expenditure results in economic growth in the form of an increase in the gross domestic product (GDP) above the value of the injection (which automatically becomes part of GDP). The injection has this effect because the money injected is then spent by those who receive it, and thus generates further production so as to make the goods and services on which the money is spent available.

Unfortunately, most of the work on multipliers has been done in the "advanced economies" rather than in developing, emerging or middle-income countries. The World Health Organisation's Investment Case paper(Dr. Bernice Dahn, 2015) utilises a multiplier of 0.7, which it cites as a World Bank estimate of the spending multiplier in developing countries. The question then arises as to whether this is an appropriate estimate for South Africa.

The basic formula underlying the multiplier is:

$$multiplier = 1/(s+t+m)$$

where *s* is the marginal propensity to save, *t* the tax rate, and *m* the marginal propensity to import.

In South Africa, the rate of savings is very low, and we assume a level of 0.1 for *s; t*axation is equivalent to about 26.5% of GDP[1] giving *t* a value of 0.265; and imports constitute about 30% of GDP(Economics, 2015), which we assume gives a level of 0.3 for *m*. Inserting these values into the formula gives a multiplier of 1.5.

An IMF paper(Nicoletta Batini, 2014) provides an alternative rule-of-thumb approach for estimating what the first-year multiplier might be for a particular country based on a range of contextual factors. They warn that the approach is based on results for advanced economies, and should be further adjusted for the specific context of a particular country at a particular time.

The first step is to calculate a score for the country based on the key contextual factors. Each contextual factor is given a score of 1 if the country's characteristic will tend to increase the multiplier, and 0 if it will not. For South Africa, the calculation would be as follows on each of the factors that might increase the multiplier:

- Low trade openness: In South Africa, the ratio of imports to domestic demand (proxied by GDP) was 31.7% in 2015, just above the 30% average for the past five years. Similarly, it was 31.3% in 2012.(Economics, 2017) On this measure, South Africa therefore just misses scoring a 1.
- Labour market rigidity: South Africa is generally categorised as having a rigid labour market where, in part due to strong trade unions, who prevent wages from falling.(2012., 2012) Here South Africa scores 1.
- Small automatic stabilisers, where the ratio of public spending is below 0.4 of GDP. In South Africa, the ratio is 0.207(Bank, 2015), well within the prescribed range, so the score is 1.

[1] Information provided by Ingrid Woolard, Dean of Commerce at University of Cape Town.

- Fixed or quasi-fixed exchange rate: Here South Africa scores 0.
- Low/safe public debt level: The cutoff point on this variable is 100% of GDP for advanced economies and it is 40% for emerging economies. In 2015, South Africa's government debt was equivalent to 50.1% of GDP.(Economics, 2016) The score is therefore 0.
- Effective public expenditure management and revenue administration. South Africa is usually regarded as a good performer in this respect and we allocate a score of 1.

Summing these scores, the total for South Africa is 4. This score suggests that South Africa is in either the "medium" or "large" multiplier category, as the range for the former is 3-4 and the range for the latter is 4-6.

The suggested multiplier range in "normal times" for the medium multiplier is 0.4-0.6 while that for the high multiplier is 0.7-1.0. Because of the uncertainty about which category South Africa should be in, we put it at 0.65, between the two ranges.

The IMF then advises a further adjustment upwards if the economy is at the lowest point of the cycle. This increases the first-year multiplier to 1.04. This is more or less the middle of the range of 0 to 2 that the IMF says can be obtained with different combinations of factors.

The IMF advises yet another adjustment of up to 30% if monetary policy is constrained. We adopt a conservative approach here and make no adjustment.

The IMF approach provides the first-year multiplier. However, the impact of an injection is not felt only in the first year. The IMF cites Mineshima et al (2014) who suggest that the second-year multiplier tends to be 10–30% higher than the first-year multiplier. This is the case for a once-off injection. Where – as would be the case for CHWs who continue to be employed – the multiplier would be further increased. Unfortunately, however, the IMF does not suggest how much the multiplier should be adjusted for ongoing injections. If we assume a 45% adjustment for a combination of going beyond the first-year and ongoing injections, then the multiplier becomes 1.5. This is the same value obtained from the simple multiplier formula.

The IMF cites Jooste et al(Charl Jooste, 2012) as estimating the South African government investment multiplier at 0.3 and government tax multiplier at 0.7. However, in our reading of Jooste et al, we found one model which produced estimates of 0.7 and 0.9 respectively, but not one which produced 0.3 and 0.7. Further, in the conclusion to their article Jooste et al state that in South Africa, "the multiplier is larger than one in countercyclical policy periods [e.g. during a recession, as at present], indicating effective expenditure."

Jooste et al's work also provides other support for South Africa having a relatively high multiplier for government injections. They do this on the basis that one of the factors that determines the impact (or size) of the multiplier is the extent to which the injected money is spent – and thus re-injected into the economy – rather than "saved" (kept for later consumption). Jooste's analysis suggests that in South Africa, because of the large numbers living in poverty, the extent to which money is saved ("propensity to save") is very low as additional money is needed for basic needs. (Jooste et al also note, in passing, that a very simple calculation of the multiplier for South Africa "often leads to rather bizarre outcomes such as multipliers equal to eight for South Africa." Their own work is based on detailed modelling using several different approaches.

Jooste differentiates between Ricardian households who save part of their income, and "rule-of-thumb households who consume their current income". They note that, logically, "one would expect the largest part of SA consumers to be liquidity constrained and given the sheer unemployment rate (at around 25%) one would expect any given income to be consumed immediately." Their empirical results provide further evidence that "South Africa has indeed a large share of liquidity constrained consumers that are unable/unwilling to save given extra income."

Both the IMF and Jooste et al consider injections in general, without considering who receives the money. The fact that the CHW injection would involve payments to poor households, would increase the likelihood that very little is saved, thus tending to increase the multiplier. The fact that the money accrues to poor households might well also decrease the reducing effect of the open economy as poorer people are less likely to buy many imported goods and services.

Finally, a World Blank blog(Raj, 2012) again argues that a larger marginal propensity to consume (i.e. lower propensity to save) will result in a larger fiscal multiplier. The blog notes that historically government spending multipliers have been estimated to lie between 1.5 and 2. The blog also cites Vegh et al (2009) who found that multipliers tend to be higher for emerging and developing countries than for advanced and high income countries.

Based on these three sources and the reasoning above, we use a multiplier of 1.5 for the CHW injection.

The value of 1.5 represents the cumulative impact on GDP achieved over a series of years as the full impact is not seen in the first year. For the purposes of modelling, we assume that the full impact is felt in the third year, with the impact at 1.2 (i.e. double the value of the injection) in the first year, 1.4 in the second year (an additional 0.2), and 1.5 in the third year (an additional 0.1). The cumulative impact of this injection would translate into R13.6 billion added to the GDP.

Table 11. Impact of additional salaries injection on GDP

	Year 1	Year 2	Year 3	Total
Multiplier	1.2	0.2	0.1	
Impact on GDP in millions	11,977	1,089	544	13,610

Creating female-dominated jobs

Creating additional jobs has benefits not only because of the growth it can stimulate in the economy through the multiplier, but also because of the personal benefits it brings to the job-holders, their families and communities.

Arcand et al(Jean-Louis Arcand, Forthcoming) suggest that health employment is especially important for rural economic development, as it generates income in areas where this is scarce. Further, availability of health services in an area can make it more attractive to businesses, as well as to professionals who might otherwise be loath to live in these areas. A similar argument could be made in respect of employment in poorer urban areas.

Overall, health employment is dominated by women. This is especially the case at lower levels and, in particular, among CHWs. There are several reasons why creating jobs for women is especially beneficial.

There is no question of the dire need for job opportunities for women in South Africa. Statistics South Africa's Quarterly Labour Force for the first quarter of 2017 produced an overall official unemployment rate of 27.7%. This is bad enough in itself. However, the female rate was even higher, at 29.8%. The overall expanded unemployment rate was 36.4%, and 40.0% for women. Expressed differently, four out of every ten women who wanted to work did not have a job of any kind, whether formal or informal.

An IMF discussion note(Elborgh-Woytek, 2013) discusses available evidence on the "significant" macroeconomic gains that result when women can realise their full potential in the labour market. They also cite an ILO paper(Heintz, 2006) which suggests that women's paid and unpaid work is the most important poverty-reducing factor in developing countries. The ILO paper in turn cites evidence that gender inequalities can impact negatively on economic growth even in the short run.

There is widespread recognition that giving money to poor women is more likely to result in benefit for other members of the household, and particularly children, than giving money to poor men. This recognition has resulted in many of the social grant systems world-wide targeting women as grant recipients. In 2012, Yoong et al(Yoong J, 2012) published a systematic review of research that investigated the differential impact of transfers to women and men. They identified 5,774 studies that had some relevance, of which 15 were usable for the systematic review in that they explicitly compared the outcomes of transfers to women and men. Of the 15, all but two found that transfers to women produced better outcomes than transfers to men. In particular, child nutrition and health outcomes were better. The 15 studies investigated a range of different types of transfers – four looked at unconditional cash transfers, three at conditional cash transfers, two at enterprise grants for households, and six at micro-credit. There is no reason to think that money flowing to women through employment would yield a different result. The IMF discussion note cited above specifically notes that a higher female labour force participation rate and female earnings is likely to result in higher expenditure on children's education. Similarly, the discussion refers to studies that show that the share of a family's resources spent on family well-being tends to increase when women account for a larger share of the household's income.

In South Africa there is ample evidence of the diverse positive impacts of the child support grant. For example, a recent summary of the evidence points to positive impacts on child nutrition, health, school, protection of adolescents from risk, increased household resilience, and potential increases in productivity and earnings when the child beneficiaries become adults.

The overwhelming majority of the child support grants have a woman as the recipient, and there is no research that compares what the impact is for male versus female recipients. Nevertheless, the fact that positive impacts are evident even with such a small-sized grant (R380 since April 2017) gives a good sense of what can be achieved when money is channeled to women with children in their care.

South Africa has an unusually large proportion of women who alone bear responsibility for providing for the financial and other needs of their children. In 2014, three-quarters of children under 18 years lived with their biological mother, compared to only 39% who lived with their biological father, while only a third of children lived with both parents. In the poorest quintile, only 17% of children lived with both parents. Among those who do not live with a father who is alive, 28% of children never see the father and a further 5% either do not know who their father is, or do not know where he is. Only 39% of those who

are not living with their fathers are supported financially by them. In Statistics South Africa's 2010 national time use survey, more than 80% of men living with children under seven years of age did not spend any time on child care in the previous day.(D., 2016) These statistics give a sense of how in South Africa in particular money accruing to women is far more likely than money accruing to men to benefit children and the next generation.

Productivity

Lauer et al(Jeremy A. Lauer, Forthcoming) observe that health employment creates a positive externality by improving the quality and quantity of labour, and thus contributing to economic output (which is what GDP measures). They counter a view of the health sector as "unproductive" by citing empirical research by the World Bank that shows countries with more developed health systems exhibiting higher productivity in manufacturing. They suggest that improvements in the health system in countries in which it is less well developed are likely to have a greater impact than similar improvements in wealthier countries.

The final report of the expert group to the High-Level Commission on Health Employment and Economic Growth(Richard Horton (Chair), 2016) emphasises that its concern is with inclusive growth, which it defines as growth whose benefits are enjoyed equitably across the population. The report presents and then counters Baumol's idea of a "cost disease". The cost disease argument sees labour-intensive sectors, such as health, as holding back economic growth because productivity will not increase at the same pace as in less labour-intensive sectors, yet wages will increase so as to prevent the labour supply moving to other sectors. This would result in wage growth higher than productivity growth.

The report notes that while initial research in developed (OECD) countries provided some support for the "cost disease" hypothesis, the results changed when research was extended to low- and middle-income countries. They cite World Bank findings that wage increases above productivity increases are not the driver of health expenditure. The World Bank also observed how health expenditure could contribute to increases in productivity in other sectors through improvements in the health of working people.

The expert group suggests that economic growth benefits will be higher for health expenditure that focuses on community-based health programmes, primary prevention and chronic conditions. All these characteristics are found in the work typically done by CHWs.

Invisible economic benefits

The Investment Case paper(Dr. Bernice Dahn, 2015) notes the difficult choices that face poor families when there is illness in the household if they live far from health facilities. In particular, such families must consider the time and money they will expend in reaching the health facility and any user fees they might incur. Implicitly this observation highlights that the presence of CHWs close to people's homes can bring monetary and other savings beyond government – in this case to some of the poorest members of society

To the extent that CHWs provide care and keep community members healthy, they also can reduce the time that women, in particular, spend caring for ill members of the household. Such unpaid work can have

monetary implications if the need to care for other members of the household inhibits women's paid work.

Additional productivity of increased health status of the population

By averting deaths, CHWs contribute to make available an additional workforce. We used the methodology presented in the WHO-led investment case for CHWs (WHO, 2015) to calculate the additional productivity of a healthier population and its impact on the GDP. For each of the tracer conditions presented we calculated for each death averted the number of years of productive life (18-60 years old). We assumed that the productivity for each of these years is equal to the country GDP per capita. We assumed a yearly increase of 1.5% of the GDP, and a 3% discount rate. Over 10 years the added productivity caused by the CHW intervention would add R413,194 billion to the country GDP.

Table 12. Additional productivity due to avoided deaths

Added productivity	# deaths averted over 10 years	Average age	Productive Years 18-60 years	Discount rate	DALYS averted per death averted	Productive DALYS averted	GDP per capita Rds 2017	Cumulative contribution to GDP in millions
Children	33,741	2,5	42	3%	24	811,768	78,254	66,139
HIV	96,923	29	31	3%	20	1,974,073		160,839
TB	60,642	36	24	3%	17	1,048,269		85,408
Hypertension	6,588	53	7	3%	6.4	42,166		3,435
Diabetes		53	7	3%	6.4	1,195,112		97,372
Total								413,194

References

2012., F. J. 2012. The Cost of Rigidity: The Case of the South African Labor Market. ERSA working paper 290. . *Economic Research Southern Africa.*

2016., G. A. 2016. No small change: The multiple impacts of the Child Support Grant on child and adolescent well-being. *South African Child Gauge 2016.* Cape town: Children's Institute, University of Cape Town.

BANK, W. 2015. *General government final consumption expenditure (% of GDP)* [Online]. Available: http://data.worldbank.org/indicator/NE.CON.GOVT.ZS.

CHARL JOOSTE, G. D. L., AND RUTHIRA NARAIDOO 2012. Analysing the effects of fiscal policy shocks in the South African economy. Economic Research Southern Africa (ERSA)

D., H. K. B. 2016. Children's contexts: Household living arrangements, poverty and care". *South African Child Gauge.* Cape Town: Children's Institute, University of Cape Town.

DR. BERNICE DAHN, D. A. T. W., DR. HENRY PERRY, DR. AKIKO MAEDA, DREW VON GLAHN, DR. RAJ PANJABI, NA'IM MERCHANT, KATY VOSBURG, DR. DANIEL PALAZUELOS, DR. CHUNLING LU, JOHN SIMON, JEROME PFAFFMANN, DANIEL BROWN, AUSTIN HEARST, PHYLLIS HEYDT, AND CLAIRE QURESHI. JULY 2015. 2015. Strengthening Primary Health Care through Community Health Workers: Investment Case and Financing Recommendations. Geneva: World Health Organization.

ECONOMICS, T. 2015. *South Africa - Imports of goods and services (% of GDP)* [Online]. Available: https://tradingeconomics.com/South Africa/imports-of-goods-and-services-percent-of-gdp-wb-data.html.

ECONOMICS, T. 2016. *https://tradingeconomics.com/South Africa/government-debt-to-gdp* [Online]. Available: https://tradingeconomics.com/South Africa/government-debt-to-gdp.

ECONOMICS, T. 2017. *South Africa Imports of goods and services percent of GDP* [Online]. Available: https://tradingeconomics.com/South Africa/imports-of-goods-and-services-percent-of-gdp-wb-data.html;%20https://datamarket.com/data/set/12o1/imports-of-goods-and-services-of-gdp#!ds=12o1!dyb=5r.5u.60.5s.62.1m.68.5p&display=choropleth&classifier=natural&numclasses=5&map=world.

HEINTZ, J. 2006. Globalization, Economic Policy and Employment: Poverty and Gender Implications. Geneva: Internaitonal Labour Organization

JEAN-LOUIS ARCAND, J. C., IBADAT DHILONA, JEREMY LAUERA, TANA WULIJIA, PASCAL ZURNA Forthcoming. The Relationship between Health Employment and Economic Growth.

JEREMY A. LAUER, A. S., EDSON ARAUJO, DAVID WEAKLIAM Forthcoming. Pathways: the health system, health employment, and economic growth.

KATRIN ELBORGH-WOYTEK, M. N., KALPANA KOCHHAR, STEFANIA FABRIZIO, KANGNI KPODAR, PHILIPPE WINGENDER, BENEDICT CLEMENTS, AND GERD SCHWARTZ 2013. Women, Work, and the Economy: Macroeconomic Gains from Gender Equity. IMF Discussion Note. IMF.

NICOLETTA BATINI, L. E., LORENZO FORNI, AND ANKE WEBER 2014. Fiscal Multipliers: Size, Determinants, and Use in Macroeconomic Projections. International Monetary Fund.

RAJ, N. 2012. *Re-thinking Fiscal Multipliers* [Online]. Available: http://blogs.worldbank.org/growth/print/re-thinking-fiscal-multipliers.

RICHARD HORTON (CHAIR), E. C. A., HAROON BHORAT, SASKIA BRUYSTEN, CLAUDIA GABRIELA JACINTO, BARBARA MCPAKE, K SRINATH REDDY, RITVA REINIKKA, JEAN-OLIVIER SCHMIDT, LINA SONG, VIROJ TANGCHAROENSATHIEN, SYLVIA TRENT-ADAMS, DAVID WEAKLIAM, ALICIA ELY YAMIN 2016. Final report of the expert group to the High-Level Commission on Health Employment and Economic Growth. WHO.

WHO 2015. Strengthening Primary Health Care through Community Health Workers:Investment Case and Financing Recommendations. Geneva: WHO.

YOONG J, R. L. D. S. 2012. The impact of economic resource transfers to women versus men: a systematic review. Technical report. London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

STAFFING NORMS

In order to calculate the cost of the platform, the number of CHWs required needs to be quantified, itself dependent on the number of home visits required for the non-insured population of South-Africa and on the time per week spent by CHWs on activities other than home visits.

Home visits needs

Methodology

The target number of home visits for the uninsured population was modelled using the following steps:

1. Size uninsured population: population projection by age and sex for 2017, number of households and medical aid coverage were obtained from StatsSA
2. Relevant denominator populations were calculated for the various types of home visits of conditions:
    a. Children under 1, from which the number of pregnancies was extrapolated applying a factor of 1.04 as per the District Health Information System calculations
    b. Children under 5
    c. Population over 40
3. Burden of disease was assessed through the following information:
    a. HIV population prevalence from the Thembisa model
    b. Population requiring ART, assumed to be 100% of HIV positive as per Test and Treat policy
    c. Population already on ART from Thembisa model
    d. TB incidence from the WHO Global TB report
    e. MDR incidence as % of new TB cases
    f. Malaria prevalence, communication from NDoH
    g. Prevalence chronic disease (under and over 40), communication NDoH
    h. Prevalence Mental health requiring treatment, Williams & al, 2007
    i. Prevalence Palliative Care for Category 3 patients from Hospital Palliative Care Association of South-Africa
4. Home visits are broken down into the following types following the latest CHWs scope of practice
    a. Household registrations (smaller number than in year 1 as many households are already registered)
    b. Household screening (yearly for all households and includes HIV testing)
    c. Additional visits to socially vulnerable households
    d. Ante-natal visits
    e. Post-natal visits
    f. Under 1 children
    g. Children aged 1 to 4
    h. on ART at beginning of Year (visits for defaulters or 50% not part of support group)
    i. New ART + TB (visits for defaulters since monthly clinic visits with treatment support)

j. New ART no TB (visits for defaulters since monthly clinic visits with treatment support)
k. TB only new cases (treatment support)
l. MDR TB 1st 6 months
m. MDR TB 2nd 6 months Year 1
n. MDR TB 2nd Year
o. Chronics (Hyper Tension, Diabetes, Asthma) under 40
p. Chronics (Hyper Tension, Diabetes, Asthma) over 40
q. Mental Health requiring support
r. Malaria
s. Palliative care

5. Number of expected home visits were calculated by type of visit by applying to the relevant denominator population the prevalence of the condition, the suggested coverage and the normative number of CHW visits per year per case.
6. Some home visits are longer than the routine home visit. This is the case for registration, annual household screening and palliative care/home-based care. These visits are given a weighting of 1.8 or 2. **Home visits equivalents** are calculated per type of visit as number of home visits multiplied by the relevant weighting.
   - The number of home visits equivalent is then recalculated to factor in the number of visits where patient has more than 1 condition (estimated 1%) and to reflect the number of patients seen per home visit, calculated at an average of 1.1 people per home visit ((ref: Resource Requirements for Community-Based Care in Rural, Deep-rural and Peri-urban Sub-districts. A comparative analysis in 2 districts in Gauteng and KwaZulu-Natal. 2017, Daviaud E., Besada D., Eager D., http://www.mrc.ac.za/healthsystems/CBCReport.pdf)
7. This final number is presented for the uninsured population of South-Africa.

Support groups and individual counselling (apart from Home HIV testing) are carried out at the clinic by clinic-based CHWs (lay counsellors). They are not included in the calculations above which focus on home visits.

Results

The StatsSA projections puts the 2017 population at 56.73 million and the medical aid coverage at 17%. The uninsured population, the target population for this study, stands at 47 million. With an average household size of 3.8, the number of uninsured households is 12.39 million.

The prevalence/incidence of different conditions is presented in the table below.

Table 13. Prevalence/Incidence per condition

Burden of Disease			Target Population
HIV/AIDS	HIV Population Prevalence	12.7%	Total Population
	Total HIV+ Population	7,205,058	
	Percentage HIV+ requiring ART	100%	HIV+
	Number already on ART at beginning Year (UNINSURED)	3,327,604	
	Planned coverage of New ART needs	50%	
TB	TB Prevalence New Cases	0.83%	Total Population
	MDR Prevalence as % of New TB cases	1.8%	New TB Cases
	Death Rate in first 6 months MDR Treatment	16.0%	MDR patients
MALARIA	Malaria Prevalence	0.02%	Total Population
CHRONIC	Chronic Disease Children & under 40	12%	Under 40
	Chronic Disease 40+	35%	40+
MENTAL HEALTH	Mental Health Requiring Treatment	17%	5 & over
PALLIATIVE	Palliative Care	0.75%	Total Population
BED-RIDDEN	Bed-Ridden requiring Home-Based Carers	0.75%	Total Population

The modelling of the number of home visits required for the uninsured population of South-Africa is presented in the table below.

Table 14. Modelling number home visits

CHW Key interventions	Population Reference	Size Population	Prevalence	Coverage	Total Number Cases	% Support group only	% Medium Intensity Home Visits	% High Intensity Home Visits	Number Home Visits per Case Medium Intensity	Number Home Visits per Case High Intensity	Home Visit Time Equivalent	Time weighted Number Home Visits Equivalent
Household Registration	All households	12,391,625	25%	75%	2,323,430		100%		1		1.5	3,485,144
Household screening	All households	12,391,625	100%	65%	8,054,556		100%		1		2.0	16,109,112
Additional Social Vulnerable households incl Alc & Substance Abuse	All households	12,391,625	25%	50%	1,548,953			100%		3	1.0	4,646,859
ANC	Under 1 * 1.04	1,011,915	100%	80%	809,532		50%	50%	2	8	1.0	4,047,660
PNC	Under 1 * 1.04	1,011,915	100%	90%	910,724		65%	35%	3	4	1.0	3,050,924
CHILDREN	Under 1	972,995	100%	80%	778,396		65%	35%	3	5	1.0	2,880,066
	1 to 4	3,891,981	100%	70%	2,724,387		65%	35%	3	5	1.0	10,080,230
HIV testing	Total Population	47,088,173	87%	5%	2,055,399						2.0	4,110,798
HIV	Total Population	47,088,173	13%		5,980,198							
on ART at beginning of Year		3,327,604		100%	3,327,604	50%	35%	15%	2	4	1.0	4,325,886
ART Initiations required this year	HIV - on ART	2,652,594	100%	50%	1,326,297							
TB	Total Population	47,088,173	0.8%		392,715							
New ART + TB	ART Initiation Cases	392,715	60%	35%	82,470			100%		4	1.0	329,881
New ART no TB	ART Initiation Cases			35%	1,243,827			100%		4	1.0	4,975,306
TB only new cases	TB cases-TB&ART	310,245		80%	248,196			100%		16	1.0	3,971,138
MDR TB 1st 6 months	TB New Cases	392,715	1.80%	95%	6,715		0%	100%	13	6	1.0	40,293
MDR TB 2nd 6 months Year 1	MDR 1st 6 months-Deaths	5,641	100%	95%	5,359	75%	60%	40%	26	52	1.0	195,065
MDR TB 2nd Year	MDR 2nd 6 months Year 1	5,359	100%	95%	5,091	75%	50%	25%	3	6	1.0	15,273
Chronics (HT, Diab, Asthma) u	Under 40	34,448,968	12%	50%	2,066,938	75%	20%	20%	3	6	1.0	3,720,489
Chronics (HT, Diab, Asthma) o	40+	12,639,205	35%	50%	2,211,861	30%	20%	20%	3	6	1.0	3,981,350
Mental Health requiring supp	5 and over	42,223,197	17%	50%	3,483,414	30%	50%	20%	4	6	1.0	11,146,924
Malaria	Total Pop	47,088,173	0.02%	95%	8,947	0%	90%	10%	1	2	1.0	9,841
Palliative care	Total Pop	47,088,173	0.8%	70%	247,213			100%		20	1.0	4,944,258

These activities can be regrouped into broader categories to quantify distribution of home visits as presented below

Table 15. Distribution of home visits

CHW Home visits	% of time
MCHW	19%
HIV/AIDS	27%
TB	8%
Chronic	36%
Palliative care	10%
Total	100%

After adjusting for condition overlap and number of patients seen per home visit, the total number of home visits equivalent for the South-African uninsured population stands at 81 million a year. This is the equivalent of 1.7 home visits per capita adjusted for time, or 1.6 home visits per capita not adjusted for time.

Number of households per CHW

Methodology

Having calculated the number of home visits required for the 2017 uninsured population of South-Africa, the following steps were taken to assess the target number of households per CHW in urban, rural and deep-rural settings:

- Assessment of time available for work per CHW per year
- Assessment of activities, other than home visits, which have to be undertaken by CHWs
- Time quantification of these activities per CHW
- Calculation of time available for home visits per CHW in number of days per week
- Definition of number of home visits per day which can be carried out by a CHW in urban areas, based on the analysis of CHW time utilisation in KZN and Gauteng[2]
- Calculation of number of home visits per day per CHW in rural and deep-rural areas by applying ratio of rural to urban and deep-rural to urban extracted from previous study[3]
- Calculation of number of home visits per year per CHW in urban, rural and deep-rural areas
- Calculation of the population which can be covered by CHW in urban, rural and deep-rural areas applying the number of home visits per capita previously calculated
- Calculation of number of households per CHW per year, applying the average size of household

Results

A CHW will be available for work for 221 days a year, being off for week-ends, 20 days annual leave, 10 days public holidays and 10 days sick leave. A CHW will work an average of 6 hours a day, 30 hours a week.

[3] Resource Requirements for Community-Based Care in Rural, Deep-rural and Peri-urban Sub-districts. A comparative analysis in 2 districts in Gauteng and KwaZulu-Natal. 2017, Daviaud E., Besada D., Eager D., http://www.mrc.ac.za/healthsystems/CBCReport.pdf

Table 16. Number of working days available per year per CHW

	Days NOT Available				Days Available	Work Weeks Equivalent / Year
Total Days / Year	Weekends	Annual Leave	Public Holidays	Sick Leave		
365	104	20	10	10	**221**	44.2

An average of 58 days a year will be spent by CHWs on activities other than home visits. These include updating the resource profile of the community, organizing and participation in health days, community meetings, visits to institutions available in the patch (ECD, old age homes), participation in epidemic response (an average of 1 day is calculated as a minority of patches will require this across the country), time in facility for supervision and admin and days spent on training.

Table 17. CHW activities other than home visits

Days per Year NOT available for Home Visits	Number per Month	Number Days per Year	
Developing Resource Profile of Community	0	2	Shorter time in second year, 10 days in 1st Year
Specific health days Cty	0	10	
Community meetings …	0.5	6	
School health follow-up	0.05	0.6	
Creche, ECD institutions	0.2	2	not all CHW patches will have these institutions
Other institutions	0.3	3	
Epidemic Response		1	averaged across the country
Facility Days incl supervision/admin	2.5	28	half-day for 3 weeks, 1 day 4th week
Training		6	
Total		58	

Given the 221 work days available per year, these 58 days will translate in the equivalent of 1.3 days a week on non-home visits activities, leaving the equivalent of 3.7 days a week available for home visits (74% of their total time). CHWs have to report to the clinic every morning where they also eat, leaving an average of 5 hours a day in the field. The study on CHW time utilisation shows that in urban areas, CHWs take a median time of 50 minutes per home visit (travel time and time in home combined) giving an average of 6 home visits per day in urban areas.

The same study shows that for rural areas an additional 33% of time must be added and 62% in deep-rural areas. In rural areas, CHWs can make an average of 4.5 home visits a day and 3.7 a day in deep-rural areas. Spending the equivalent of 3.7 days a week on home visits, a CHW can make an average of 22 home visits a week in urban areas, 17 in rural areas and 14 in deep-rural areas.

With an average of 1.7 home visits per capita per year, and 3.8 people per household, in urban areas a CHW can be allocated 150 households, 113 in rural areas and 92 in deep rural areas.

Table 18. Number households per CHW per year

	Urban	Rural	Deep Rural
Days per Week for			
Home Visits		3.7	
Not Home Visits		1.3	
Ratio to Urban	1.0	1.3	1.6
Home Visits per Day per CHW	6.0	4.5	3.7
Home Visits per Week per CHW	22	17	14
Home Visits per Year per CHW	978	735	604
Number home visits per capita per year	1.7	1.7	1.7
Number people per household	3.8	3.8	3.8
Households per CHW	150	113	92

According to Stats SA 65% of population lived in urban areas in 2015. We assumed that 20% of the population lives in rural areas and 15% in deep-rural areas. Applying the number of households per CHW and the distribution of households between urbans, rural and deep rural, the total number of CHWs required for the country would stand at 95,962. Applying policy norm of 10 CHWs per team, just under 9,600 teams would be needed for the country.

Table 19. Number CHWs and number of teams

	Urban	Rural	Deep Rural	Total
Number CHWs required	53,818	22,024	20,120	95,962
Total number of Teams SA	5,382	2,202	2,012	9,596

COSTING

Costing of the platform was done from the provider (health system) perspective, assuming an adequately equipped and supported team. It did not include costs paid by CHWs.

Methods

We used the number of CHWs and number of teams required as calculated in the previous section. As per current guidelines regarding WBOTs, each team is supervised by a full-time dedicated staff nurse: the Outreach Team Leader (OTL).

Costs are separated into set-up and recurrent costs. Set-up costs cover equipment (staff lockers, team laptop, cell phones for the team leader and each CHW, kits) and training. Infrastructure costs were not included as CHWs operate mostly from existing structures and these costs are reflected in the 10% overheads. Recurrent costs include salaries (from assistant director for community-based care to supervisors (OTL) and CHWs), administration fee, supplies (airtime, stationery, equipment maintenance) and kit replenishment, and 10% overheads. Set up costs are annualised, using straight depreciation, as they are not one-off costs and have to be repeated according to each item's length of life. Recurrent costs reflect 1 year costs.

Equipment: a laptop per team was costed at R10,000 purchase price, reflecting a below average price laptop but offering enough functionality for the envisaged use. Similarly, cell phones were costed at R1000 each. The kit was costed at the current cost of a well-equipped kit in the Gauteng province to which we added gloves and masks. Salaries of assistant director and staff nurses reflected mid-point salaries for that category of staff in government employ. Benefits equivalent to 37% of salaries were added. CHWs' stipend was set at R3,500. The standard administration fee of 10% for these stipends was added to reflect the cost of the administering NGO or paying structure. Supplies included a monthly voucher of R150 airtime for CHWs and R500 for the OTL. Stationery was costed at R2,500 a year, as was equipment maintenance. A 10% overhead was added to the sub-total of annualised set-up costs plus recurrent costs. Costs are expressed in 2017 Rands.

Results

For South Africa's uninsured population 9,596 teams would be required with 9,596 team leaders and 95,962 CHWs. The 52 assistant directors, 1 per district, would spend 66% of their time on WBOT teams.

The yearly total financial costs would amount to R8.8 billion, or R92,135 per CHW, representing their stipend and training, supervision, equipment, overheads. This is equivalent to R156 per capita total population. The R8.8 billion would represent 17.6% of the current public sector PHC expenditure, a significant increase compared to the current situation where evaluations in 2 districts with more developed WBOTs platforms show that expenditure on WBOTs represented under 4% of PHC expenditure. About R2 billion is currently being spent on the CHW platform. The additional amount would thus stand at R6.8 billion.

If WBOTs were deployed only amongst populations of wealth quintiles 1 and 2 (the poorest of the 5 quintiles), the total cost would amount to R3.5 billion.

Table 20. Cost of the WBOT platform

SA costs in Rds 2017		Unit Cost	Quantity	Life Years	% for WBOT	Annualised Cost for SA	Annualised Cost per CHW
Set-up							
	Equipment						
	Staff Locker	849	96,030	10	100%	8,152,930	85
	Cell phone CHWs	1,000	96,030	2	100%	48,014,901	500
	Cellphone OTL	1,000	9,603	2	100%	4,801,490	50
	Laptop per team	10,000	9,603	5	100%	19,205,960	200
	Uniform per CHW	1,200	96,030	2	100%	57,617,881	600
	Equipment: kits	2,495	96,030	2	100%	119,797,177	1,248
	Training CHWs	6,000	96,030	5	100%	115,235,762	1,200
Recurrent	Salaries/Stipends						
	Asst Director CBS	426,000	52	1	66%	14,620,320	152
	Staff Nurse (OTL)	251,244	9,603	1	100%	2,412,691,141	25,124
	CHW WBOTs	42,000	96,030	1	100%	4,033,251,656	42,000
	Administration fee @10%	4,200	96,030	1	100%	403,325,166	4,200
	Supplies						-
	Cellphone time CHWs	1,800	96,030	1	100%	172,853,642	1,800
	Cellphone time OTL	6,000	9,603	1	100%	57,617,881	600
	Stationary per CHW	2,500	96,030	1	100%	240,074,503	2,500
	Equipment maintenance	2,500	1	1	100%	2,500	0
	Kit replenishment per CHW	3,500	96,030	1	100%	336,104,305	3,500
	Subtotal					8,043,367,214	83,759
	Overheads (room, electricity…) 10%					804,336,721	8,376
ANNUALISED	Total					8,847,703,936	92,135

COST-EFFECTIVENESS, COSTS AND SAVINGS OF THE CHW PLATFORM

Earlier sections have analysed the cost-effectiveness of CHW interventions for tracer conditions along the course of life. They are summarized in the table below. All these interventions, except hypertension, with higher case-finding and better retention in treatment are highly cost-effective with a cost per DALY averted below the country GDP per capita. Services for hypertension at a cost above the GDP per capita would be cost-effective. Furthermore, interventions for HIV/AIDS and TB are cost-saving through avoiding further transmissions, drug resistance and enabling cheaper treatment.

Table 21. Cost-effectiveness of the CHW platform

Interventions	DALYs averted over 10 years	Incremental Cost per DALY averted	GDP per capita	Comment
Mother and Child	964,587	18,013	78,254	highly cost-effective
HIV/AIDS	1,061,669	- 19,999		highly cost-effective and cost saving
TB	1,002,592	- 2,121		highly cost-effective and cost saving
Hypertension	73,716	105,051		cost-effective
Diabetes	1,662,912	6,096		highly cost-effective

The adequately resourced CHW platform would not translate into additional cost for the health sector, rather it would save R29.9 billion for the health sector over 10 years. In addition it would add R426.8 billion to the GDP through the multiplier effect of increased employment and added productivity of a healthier population.

Table 22. Costs and savings of the CHW platform

Interventions	Cost/Saving in R millions	Addition to GDP
Mother and Child	14,937	
HIV/AIDS	- 21,233	
TB	- 2,911	
Hypertension	7,744	
Diabetes	1,313	
Palliative care	- 29,750	
Multiplier effect		13,610
Higher productivity		413,194
Total	- 29,901	426,804

Sensitivity analysis

If a 5% discount rate, as opposed to a 3% discount rate, is applied to the benefits to the economy, the amount contributed to the economy by the multiplier and the added productivity would be R346 billion.

DISCUSSION

Community health platforms are in many countries patchy, under resourced and with unsecured budgets. As a consequence their impact has been suboptimal. However numerous studies have shown the potential of optimally performing CHWs interventions, showing significant numbers of deaths averted, DALYs averted and financial savings for the health system.

To ensure adequate and on-going resourcing of the CHW platform, the government must satisfy itself that such investment is justified by the returns it brings. Returns can be expressed in improved health status through CHWs interventions and by the impact of added employment and improved health status on the economy and society. Return on investment was the focus of this investment case.

Whilst based on results from a literature review, the modelling has used a conservative approach, avoiding spectacular impact results often associated with well-resourced and intensively supported trials not easily replicable on an on-going basis. In addition, due to the time for this study it has not been possible to study the impact on co-morbidities, thus understating the true impact of CHWs.

Despite this conservative approach and scope, all interventions by CHWs in the fields of mother and child health, HIV/AIDs, TB, Hypertension and Diabetes would lead to a decrease of just under 200,000 deaths over 10 years and to 4.8 million DALYs averted. Hypertension services by CHWs has been shown to be cost-effective by WHO thresholds with cost per DALY averted below 3 times the GDP per capita. All other interventions presented have been shown to be highly cost-effective, with a cost per DALY averted mostly very significantly lower than the country GDP per capita. In the areas of HIV/AIDs, TB and palliative care, CHWs interventions are in fact cost-saving for the health-system. Combining all interventions and the cost of the platform a saving of just under R30 billion will be made over 10 years.

If the health sector would benefit from this strong CHW platform, the economy and society at large would also benefit. The injection of the added salaries - mainly to poor women- will be spent rather than saved, and will translate into an amount of R13.6 billion added to the country GDP over the first 3 years due to the multiplier effect. In addition, the better health status of the population and the deaths averted through the CHWs interventions, translate into an additional 5 million productive life years added to the workforce over 10 years. The consequent increase in productivity would add R413 billion to the GDP.

A highly performing CHW platform would create very substantial savings for the country.

Some interventions have been shown to be cost saving or incur a low cost per health impact when others, whilst cost-effective or highly cost-effective, have a higher cost per health impact. Should CHWs interventions be limited to interventions with low cost? In line with the policy on CHWs in South Africa, the CHW platform is an integrated platform where CHWs are generic workers covering a continuum of conditions following the life course. These interventions are not independent from each other and often have an additive impact by being delivered together, even if this additive impact has not been quantified in this study. Diabetics have a much increased risk of contracting TB or being hypertensive. The same home visit will support case finding or adherence to treatment for these three conditions. In addition, reducing the number of interventions in order to increase the population covered by each CHW and thus reducing the number of CHWs is not feasible. CHWs travel by foot and have no transport allowance. A larger geographical patch per CHW would make walking to the more distant homes impossible.

In order to enable the benefits from the CHW platform, additional funding must be made available to build and maintain this platform. It is already partly funded by the government to the tune of approximately R2 billion a year. At a monthly stipend level of R3,500, an adequately trained, equipped and supported platform would require an additional R6.8 billion a year with the new suggested staffing norms. Note that the total cost of the platform has been included in the costs of the intervention, the costs per DALY averted and the savings identified. This is not solely an additional cost as it would translate into R426.8 billion being added to the GDP over 10 years due to the multiplier effect of increased employment of the additional CHWs and the added productivity of the DALYs averted.

This analysis demonstrates that investing in a sufficient number of CHWs and HBCs, while incurring significant expenditure will translate into very substantial health and economic benefits, which, in turn, will have immeasurable positive social and political impacts through better health status and increased employment.