REPORT

Synthesis Report

Capacity Building on Risk and Vulnerability Assessment Tool and Development of National Climate RVA for Health

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PROJECT BACKGROUND

This Synthesis Report presents a synthesis of the work completed, and provides options /recommendations for investments, on the project titled "Capacity Building on risk and vulnerability assessment tool and development of national climate Risk and Vulnerability Assessment (RVA) for the Health Sector", commissioned by the Deutsche Gesellschaft Fur Internationale Zusammenarbeit (GIZ) GmbH in collaboration with the National Department of Forestry, Fisheries and the Environment (DFFE) and National Department of Health (NDoH).

The objective of this assignment is to build on the previous work associated with the scoping and RVA Tool by undertaking an RVA for the health sector. This has been undertaken in two phases. Phase One focuses on scoping and planning to determine the purpose, context and to determine the required depth of the assessment, as well as the updating of the existing RVA Tool. Phase Two involves undertaking a RVA for the health sector, and provision of draft responses to the identified impacts.

Acknowledgments

Special thanks to the specialist consulting team who provided valuable input to the update of the Health Risk and Vulnerability Assessment tool, and the facilitation of the Workshops: Belynda Petrie (project lead and tool lead, workshop facilitation), Jonny Meyers (health sector expert and data analysis), Anthony Kinghorn (health sector expert, workshop facilitation) and Arthur Chapman (climate change expert, workshop facilitation). Additional thanks to the OneWorld team who have further contributed to the development and refinement of the tool and this supporting scoping report, namely: Zac Weaver (research & tool development, workshop support), Sarah Wewege (research & tool development), and Tasneem Steenkamp (research & project management, workshop facilitation).

In addition, thank you to all of the health professionals who took part in the workshops, provided the team with feedback and assisted with the completion of the Risk and Vulnerability Assessments.

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Contents

Abbreviations and acronyms

BoD	Burden of disease
CEU	Continuing Education Units
CPD	Continuing Professional Development
CSIR	Council for Scientific Industrial Research
DFFE	Department of Forestry, Fisheries, and the Environment
DoH	Department of Health
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft Fur Internationale Zusammenarbeit (GmbH) (GIZ) / German Development Agency
HRVA	Health Risk and Vulnerability Assessment
HPCSA	Health Professional's Council of South Africa
NDHB	National District Health Barometer
RPC	Representative Concentration Pathway
WHO	World Health Organisation

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Introduction

This Synthesis Report is Deliverable 11 of the **Capacity Building on risk and vulnerability assessment tool and development of a national climate Risk and Vulnerability Assessment (RVA) for the Health Sector**, commissioned by the Deutsche Gesellschaft Fur Internationale Zusammenarbeit (GIZ) GmbH in collaboration with the National Department of Forestry, Fisheries, and the Environment (DFFE) and National Department of Health (NDoH). This report serves as synthesis report of the outcomes of the district climate and health assessments, and as such builds off, and synthesises the results of the district assessments.

Following this introduction (Section 1), this report provides an assessment of relative risk data collected from all 52 districts from a national perspective. The document draws key findings, and presents key recommendations based on this data, and the expected impacts of climate change by 2050. summarises the project's scope and milestones (Section 2), describes the key project findings (Section 3), and provides recommendations and lessons learnt (Section 4), followed by the concluding remarks (Section 5).

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Project Overview

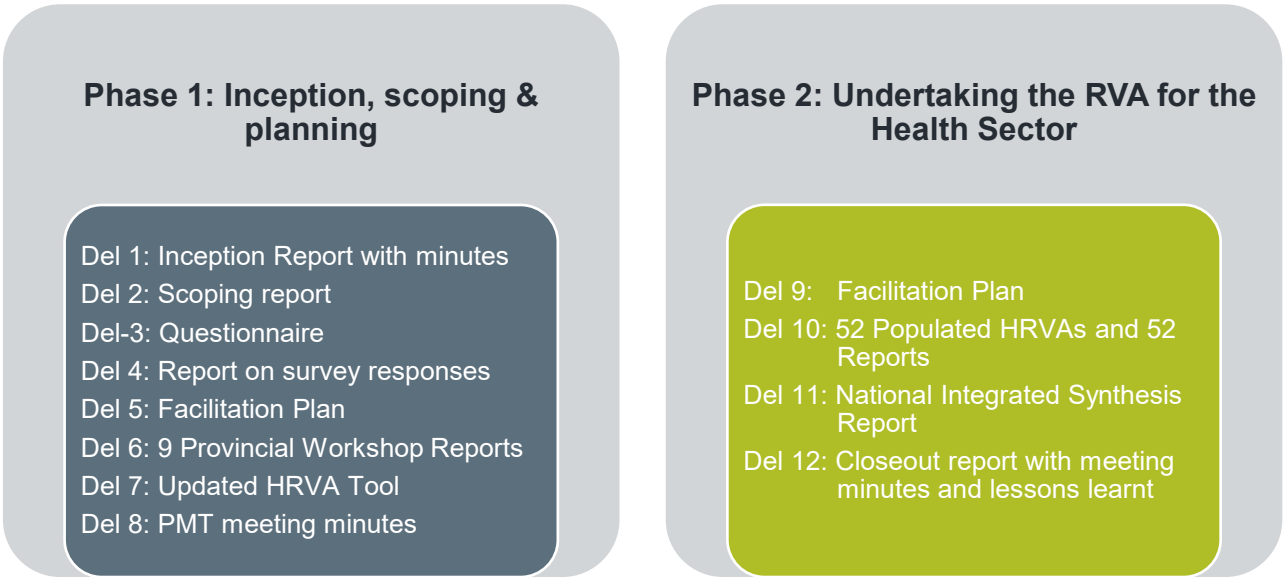
2.1 Project Description

The project was designed to build on previous scoping work and the Risk and Vulnerability Assessment (RVA) Tool developed for the South African health sector by the Council for Scientific, and Industrial Research (CSIR).

This project followed a two-phased approach, detailed in Figure 1, with an initial inception, scoping, and planning phase. This phase involved updating the initial literature review developed by the CSIR, developing a stakeholder engagement plan, and updating the RVA Tool. This phase also included the district Capacity Building, and Health Risk and Vulnerability Assessment (HRVA) Workshops. In total, three half-day Capacity Building Workshops, and seven half-day HRVA Workshops were held, alongside six full-day blended Capacity Building, and HRVA Workshops. The project initially was designed with solely in-person workshops for the capacity building, and data collection workshops with the health districts, however the COVID-19 pandemic reduced the feasibility of solely conducting in-person workshops. Initially all workshops were held online via Microsoft Teams, however, it was found that some provinces preferred to conduct in-person workshops, given existing connectivity and power access issues. As such a hybrid model of in-person and online workshops was developed based on each province's preferences and ensuring that all South African government COVID-19 protocols were followed.

Phase 2 involved processing the data gathered from the districts, and producing 52 district HRVA reports, and one national synthesis report, both of which examine the risk which climate change will pose to the health sector by 2050.

Figure 1. Project delivery through a two-phased approach



2.2 Project Delivery Overview

The following outlines the project delivery milestones, with a brief description of the tools and processes developed for the district assessments which this report synthesises.

Stakeholder Engagement and Participatory Analysis

The project team developed a stakeholder engagement plan and conducted stakeholder mapping to underpin and inform the stakeholder engagement and participatory analysis of climate change impacts on the public health sector. The plan included details of OneWorld's approach to stakeholder engagement under the constraints of COVID-19, and a proposed workshop schedule, which was later amended to accommodate the demand for and ability to conduct face to face participatory analysis as COVID-19 regulations relaxed with the concomitant ease of risk of the pandemic for South Africa at the time.

Scoping and literature review

This work sought to provide an updated review of key literature written since the CSIR's literature review was conducted. Additionally, the report included overviews of the *National Climate Risk and Vulnerability Assessment Framework* by the DFFE and the World Health Organisation (WHO)'s *Protecting Health from Climate Change Vulnerability and Adaptation Assessment*. It further sought to outline the methodology for updating the HRVA Tool, alongside the data and professional assumptions used to develop the HRVA Tool.

Updated HRVA Tool

Building off of the preceding CSIR project for developing a preliminary tool, an Excel Workbook was adapted and developed with a view to using the tool to conduct participatory analysis with district health officials, and with a view to the tool becoming a self-assessment tool for ongoing district application.

The update involved a full redesign and expansion of the Tool to allow for capacity building, data collection, and climate change data-informed, relative risk modelling of the impact of climate change on the health sector. The HRVA Tool was based off the WHO's guidelines on conducting health sector climate change risk and vulnerability assessments, the knowledge of the OneWorld team experts, and discussions with the project management team. Climate change data from the CSIR's Greenbook, and the Climate Research Unit's Time Series Climate Data was integrated into the HRVA Tool, alongside burden of disease (BoD) information from the Health Systems Trust's District Health Barometer to provide health officials with baseline health data.

The HRVA Tool was expanded to include a capacity building section. This section informed health officials on the expected impacts of climate change in South Africa, the interactions between climate change and key health outcomes in South Africa, and provided a 1st-to-4th Order Impact Assessment framework (an interactive tool for participatory analysis around climate change impacts). The capacity building sheets were followed by the data collection sheets, which collect district health officials' estimates of future vulnerability of BoD, and health services in their districts. These estimates are then overlaid with climate change data, to provide relative risk ranks which detail the potential impact of climate change on the BoD, and health services categories.

Capacity Building Workshops

A series of capacity building workshops was conducted at the provincial level, in each of South Africa's nine provinces with a view to capacitating health officials at the provincial and district level on climate change and health, and to present and review the HRVA Tool. These workshops were intended to underpin the subsequent participatory HRVAs conducted in each of the country's 52 health districts.

Survey (questionnaire) and Report on Survey Responses

A survey/questionnaire was designed and implemented to increase the understanding of how effective the health officials found the capacity building material, and to establish their opinions on the HVRA Tool. The

survey was conducted through two separate questionnaires. Firstly, during the Capacity Building Workshops the health officials were asked several questions regarding the capacity building material presented, and their initial impressions of the HRVA Tool. These questions were asked using Mentimeter in online workshops, and through verbal discussions during in-person workshops. Secondly, after the Capacity Building, and HRVA Workshops, the health officials were given a Feedback Survey (using Google Forms), which asked a more extensive set of questions on the capacity building material, and on the HRVA Tool's use and recommendations on improvements.

52 District HRVA Assessments

Participatory analysis was conducted through 52 separate District Health Risk and Vulnerability Assessments (with a report developed for each), as conducted in each of South Africa's health districts. Each assessment focussed on one health district and yielded an overview of the district's key climate change parameters, the vulnerabilities identified by district health officials, and the district's relative risk of health impacts due to climate change for BoD, and health services. In the vulnerability analysis, areas which health officials identified as not being vulnerable to climate change, but are noted in the literature as being vulnerable, were discussed to aid in the health officials' understanding of the impact of climate change on health. Further, the risk analysis includes both an identification of the areas of health at risk identified by the HRVA Tool, and explanations of how climate change is expected to impact the identified diseases, and health services. Each district report was accompanied by an HRVA Tool (an Excel workbook) populated with the district's health data, which should be read in conjunction with the district report. These reports and their respective populated HRVA Tools, constitute the information behind the synthesis analysis in this report.

3

Climate Change Risk and Vulnerability Assessment

3.1 The Climate Rationale – How Climate Change Affects Human Health

It is increasingly recognised across the world that climate change influences human health in many ways. Increasing temperatures, increasing frequency and intensity of heatwaves, increasing humidity (in some parts), flooding and sea level rise, all have an effect on human health in some way. Between 2030 – 2050, climate change is expected to cause about 250 000 deaths per year (from malnutrition, malaria, diarrhoea, heat stress), above the usual levels. The direct damage costs to health would be approximately US$2 – 4 billion per year by 2030 (WHO, 2021). This does not include injury from floods, storms, and high winds. Those areas with weak health infrastructure will not be able to support the health service demands.

The Intergovernmental Panel on Climate Change (IPCC) Working Group 2 Sixth Assessment Report (AR6) (Pörtner et al., 2022) states a very high confidence that climate-related illnesses are increasing. Awareness is growing of the projected risks of climate change on health, wellbeing, mental health, migration and conflict. Climate hazards are contributing to an increasing number of adverse health outcomes that include communicable and non-communicable diseases (Cissé et al., 2022). There are few if any observed beneficial outcomes of climate change on human health. Vulnerable populations, through poverty, are already increasingly susceptible to climate-related hazards.

The general academic literature has really only considered projected changes to human health, with climate change as a causative mechanism, *through assessing the impacts of environmental changes and an alteration of the intensity of vectors and pathways (direct and indirect) for pathogens, or exposures to hazardous conditions* (e.g. see McMichael et al., 2006). These relationships were only understood in a fairly simplistic way, with cause-and-effect qualitative descriptions only. Health considerations were about the impacts of extreme events and increasing the rates of infectious (water-borne and vector-borne) disease transmission (Patz et al., 2014). Little has changed in that time, for example Lieber et al. (2021) present a linkage to HIV/AIDS via four indirect pathways, noting that health outcomes are complex, with multiple interacting factors. There are few or no quantitative data to support numerical analyses and health impact projections on increased burden of disease as a result of climate change.

The impacts of climate change have to date mostly been of concern from a scientific (but not medical) point of view, and by scientists concerned with the general impacts of climate change since the early 1990s. This is still true even for the most recent climate change report of the IPCC (AR6). The WHO (2021) notes that it is difficult to estimate accurately the scale and impact of climate-sensitive health risks. Only now are there concerns beginning to emerge from the health and medical sectors regarding the sensitivity of human health to the impacts of climate change (Goshua et al., 2021). For these reasons, climate change has not generally entered the debate around planning for future health services and how future societies should meet the induced health challenges.

This state of affairs can be understood by viewing it through the lens (and the scale) of the HIV/AIDS crisis in Southern Africa and particularly South Africa. Medical professionals have been so deeply engaged in treating HIV infections and trying to reduce transmissions or treat the resulting AIDS and other related diseases, that climate change as a factor in the health system was seen as a relatively minor problem. There

has been no data to show an HIV/AIDS–climate change link. Chersich et al., (2018) note that the health sector in South Africa has been to-date "a fringe player" with respect to climate change awareness, research and planning. Some work has already been done, but it is limited in extent.

After HIV/AIDS, tuberculosis is the next most important human health concern in South Africa. Maharjan et al. (2021) describe a number of climate-related factors that could affect the rates of infection with tuberculosis. Correlations are made but specific mechanisms of transmission and infection are not stated. There are so many factors involved that could affect tuberculosis prevalence that projections of future prevalence, based only on a few climate trends, will be exceptionally difficult. Future tuberculosis prevalence will likely be assessed qualitative only. This is very similar to how climate change affects the incidence and severity of other respiratory infections including vectors and host immune responses (Mirsaeidi et al., 2016). The extent of the effects of climate change on respiratory disease prevalence remain unclear (Ayres et al., 2009). The same principles apply to kidney diseases as a response to increasing temperatures (Borg and Bi, 2021; Ephraim et al., 2020; Johnson et al., 2016).

There are some better conclusions for chronic lung diseases (different to pathogenic respiratory disease). Witt et al. (2015) can point to a likely rise in early onset deaths of 1.8 – 2.8% excess deaths during future heatwaves. In sub-Saharan Africa, a study of 192,000 children from 30 countries with historical climate data shows a strongly negative relationship between child weight and average temperature through the mechanism of malnutrition (Baker and Anttila-Hughes, 2020). Using the CMIP5 climate model to estimate future temperature and a continuation of current socio-economic conditions, West Africa could see a 37% increase in the prevalence of wasting by 2100 and East and Central Africa 25% (Baker and Anttila-Hughes, 2020).

Notable studies in South Africa that include empirical data include: (i) Musengimana et al. (2016), concerning temperature variability and occurrence of diarrhoea in children under five in Cape Town; (ii) the heat effects of ambient apparent temperature on all-cause mortality in Cape Town, Durban and Johannesburg (Wichmann, 2017); and (iii) the association between ambient temperature and mortality (Scovronick et al., 2018). Nevertheless, most other studies referenced by Chersich et al. (2018) do not analyse the impacts of climate change through empirical data. Focused research and effective use of surveillance data is required for the health sector in the future concerning the impacts of climate change on human health (Chersich et al., 2018).

3.2 Context of the HRVA

The Government of South Africa is taking a more holistic approach towards adaptation to climate change than in the past. Previously, climate change concerned principally the environmental and water resources sectors and studies were located within the relevant government departments, mostly the Department of Forestry, Fisheries and Environment (DFFE). Now, with greater commitments to coping with the challenge of climate changes, the requirement has been expressed that all sectors, including the health sector, be included in the ongoing work, especially as South Africa prepares its commitments to the international community as well as making progress on climate change adaptation plans.

This work takes a different approach to that developed previously by the CSIR (Garland and Rother, 2017). In the CSIR report, linkages of various health components were made to various climate parameters and projected changes, but without concerning explicit and empirical or spatial data. The linkages are clear yet the report does not consider the priority burdens of disease as they are distributed across the South African administrative regions. Each region and district likely have different priority burdens of disease, which respond to local socio-economic conditions, demographic factors and environmental conditions, including climatic.

3.3 Approach and Methods for This Study

Further details on the methodology and data used for this study appear in Appendix 1.

Given the above conclusions about the lack of empirical data in evaluating the impacts of climate change on human health in South Africa, the method devised here was to use empirical data where possible, model data for climate projections, and use stakeholder perspectives for local insights into the assessment.

Climate aspects that may affect human health vary widely across the country and there are different vulnerabilities to the impacts of climate change that vary according to local conditions. (From discussions in the workshops, it was clear, for example, that in the Eastern Cape there are concerns about flooding and impassable roads while in the north western areas, high day-time temperatures limit outdoor activity to the extent that movement ceases from 9 or 10am for ~ 7 hours, affecting attendance at health facilities for those in need. In the Limpopo Province, degradation of unpaved roads in the rainy season results in damage to ambulances. This leads to the maintenance and repair costs of the ambulance services rising to a point where their ability to reach and attend to patients is affected.)

Climate projections were taken from the CSIR's Green Book (Engelbrecht et al., 2019), in which climate projection maps and associated numerical values have been made available. For each district, a spreadsheet was populated with projections reporting the quantum of climate change concerning temperature, maximum temperature, mean rainfall and maximum (flood producing) rainfalls, as well as relative humidity. These data were obtained by projecting current trends of CRUTS data (Harris et al., 2020).

This revision of the climate change Health and Climate Change Risk Assessment methodology uses published data as inputs where possible so as to avoid inputs by people, for example in workshops, on the data aspects for which they have in reality no scientific or objective experience or understanding. This approach avoids asking health professionals for inputs on climate change parameters or knowledge of climate processes. Such an approach process is invariably lengthy and risks some bias. Nevertheless, it allows stakeholders to avoid some anxiety about commenting on problems on which they have little knowledge.

This method is also different to the CSIR tool in the way that it directly uses DOH data as well as climate change modelled outputs to create a numerical assessment of the climate-health impacts. We used the District Health Barometer (DHB) list based on the burden of disease (BoD) profiles for each district supplied by the national health department. The BoD are the ranking of the 20 leading causes of years of life lost by district. Here we use the 2017 data, which is the latest available. This method is the major departure from the CSIR approach. Here we bring in observed health data, ranked for importance (see Fig 1). While we recognise that climate change affects many different aspects of human health, we are focusing on the top 20 most important to the health services sector as that is where the greatest impact is being imposed.

The Tool

The HRVA Tool (the Tool) was designed to develop an understanding of the impact of climate change on the South African health sector, based off climate change models coupled with vulnerability data collected from district health officials in all of South Africa's 52 districts. Based off this risk data, an evidence-based understanding of risk can be developed, which is reflective of the knowledge, and understanding of the health sector. While there is a significant body of academic literature on the impact of climate change on health in South Africa, there are no comprehensive, or cross-comparable studies which estimate the future severity of burden of disease (BoD) and health services, which is needed to understand the expected vulnerabilities, and how these vulnerabilities are at risk from climate change. As such the Tool serves to address this gap in the academic literature, and to provide a comprehensive understanding of the potential risk of climate change to BoD and health services at a district level. Examples of BoDs and their ranking is shown in Figure 2.

The data in the BoD disease categories are grouped as follows:

1. Injuries
2. Major infectious diseases (HIV and TB)

3. Communicable diseases together with maternal, perinatal and nutritional conditions
4. Noncommunicable diseases

The health–climate change relationships are explained in more detail and shown in the tables in the following pages (Tables (1-4). The relationships were determined by local epidemiological expertise utilised by this project, rather than specific scientific publications that may pertain to different regions across the world.

Workshops

The project engaged health stakeholders in 52 districts, with workshops including 20–30+ people per workshop. Workshops were set up in each of the nine provinces. Some workshops took place online (given restrictions imposed during the height of the Covid-19 pandemic), whilst some took place in person in each province. The attendees were presented with the way the model works, and then taken through some examples on the 1st-to-4th Order Climate Impact Framework model (a hierarchical/cascading impacts conceptual model) with respect to human health (see Fig 3). They were then presented in combination with specific climate projections per district.

Figure 2. Example of Burdens of Disease (BoD) taken from the Departmental Health Barometer and used in this analysis (Source: District Health Barometer, South African National Department of Health).

Section A: Burden of disease

Figure 7: Ranking of 20 leading causes of years of life lost by district, 2017

Prov	District	HIV/AIDS	Tuberculosis	Lower respiratory infections	Cerebrovascular disease	Diabetes mellitus	Hypertensive heart disease	Ischaemic heart disease	Endocrine nutritional,blood, immu..	Interpersonal violence	Mechanical forces	Road injuries	Diarrhoeal diseases	Hanging, strangulation	COPD	Nephritis/nephrosis	Preterm birth complications	Septicaemia	Epilepsy	Meningitis/encephalitis	Asthma	Prostate	Sepsis/other newborn infectious	Other perinatal conditions	Malaria	Exposure to natural forces	Other transport accidents
EC	A Nzo DM: DC44	1	2	3	5	8	7	10	13	4	17	9	6	11	18	14		19	12	16	15						
	Amathole DM: DC12	1	2	3	6	7	4	17	8	5	15	11	12	9	10	20			13		14						
	Buffalo City MM: BUF	1	2	6	4	5	8	7	11	3	12			10	9	18			20		16						
	C Hani DM: DC13	2	1	4	5	7	8	9	6	3	17	15	11	10	12	20			14		13						
	Joe Gqabi DM: DC14	2	1	3	6	9	7	8	4	5		19	10	11	13	12			17	14	15						
	N Mandela Bay MM: N..	1	2	9	3	4	6	7	8	10	5	15		14	13	16			17		12						
	OR Tambo DM: DC15	1	2	4	5	9	7		8	3	11	6	10	12	19	14			15	16	18						
	Sarah Baartman DM: ..	1	2	5	4	7	8	6	10	3		11	17	14	9	18			13		15						
FS	Fezile Dabi DM: DC20	1	2	3	6	7	4	8	9	11		5	10	13	14	12	15				20						
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	Xhariep DM: DC16	1	2	4	3	8	5	6	10	7	16		13	9	15			19	14	20	11					17	
GP	City of Ekurhuleni MM:..	1	2	3	5	8	10	7	6	9	4		16	11	13	14	12	15		17							
	Johannesburg MM: JHB	1	4	3	6	10	15	5	8	7	2		20	9	12	11	14	13									
	Sedibeng DM: DC42	3	2	1	6	9	4	5	7	8	10		14	11	13	12	18	15									
	Tshwane MM: TSH	1	2	3	6	5	7	4	8		9	13	12	11	15	10	16	14									
	West Rand DM: DC48	1	3	2	8	9	11	6	4	5	7		12	10	14	17	15	13		16							
KZ	Amajuba DM: DC25	2	1	3	4	6	7	12	15	8	17	5	9	13		10	11	16	20	18							
	Harry Gwala DM: DC43	1	2	3	4	5	7	16	9	10	13	6	8	14		18	17		15		11						
	King Cetshwayo DM: ..	1	2	6	3	4	7	14	8	9	10	5	11	12		13	18	16	19								
	Ugu DM: DC21	1	2	4	3	5	7	9	10	6	11	14	12	8	16	13	17	18	19								
	Zululand DM: DC26	1	2	3	4	6	9	13	5	10	12	11	7	8		16	17	14	19	20							
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	iLembe DM: DC29	2	1	5	3	7	15	4	9		10	19	8	6		11	13	12		16							20
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	uMzinyathi DM: DC24	1	2	4	3	7	6	12	9	11	8	5	10	15	20	13	14	19	18								
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LP	Capricorn DM: DC35	1	3	2	8	6	5	14	9	12		4	7	13	16	10	11	17		18				20			
	Mopani DM: DC33	1	3	2	6	4	9	13	8	18		5	7	15		10	12	14		16					11		
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MP	Ehlanzeni DM: DC32	1	2	3	5	8	10	7	9	15	16	4	6	11		12	18	13		17					19		
	G Sibande DM: DC30	1	2	3	5	10	8	12	4	11	15	6	7	9	18	14	13	19									
	Nkangala DM: DC31	1	3	2	6	7	4	8	9	13	15	5	11	10	12	14	17	16	20								
NC	Frances Baard DM: D..	1	2	6	5	8	7	9	3	10		4	16	14	11	13	15		19								
	JT Gaetsewe DM: DC..	1	3	2	7	12	9	11	13	6		5	4			10	8		20	19							
	Namakwa DM: DC6	4	2	5	6	7	12	1	11	9		10	14	15	3		13										
	Pixley Ka Seme DM: D..	1	2	4	6	13	10	3	9	7		8	15	14	5		11	18	12								
	ZF Mgcawu DM: DC8	2	1	5	7	11	10	8	3	9		4	12	19	6	20	15		18		17						
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	Dr K Kaunda DM: DC40	1	2	3	6	10	7	9	4	5	20		12	8	11	14	13	19									
	NM Molema DM: DC38	3	2	1	6	8	5	10	4	16		9	7	15		13	11	12	18		14		19				
	RS Mompati DM: DC39	1	3	2	7	8	4	12	5	11			6	9	20	17	13	15	14								
WC	Cape Town MM: CPT	1	4	10	6	8	11	3	12	5	2	18		14	9	20	16	19									
	Cape Winelands DM: ..	1	2	9	3	8	13	6	16	4	10	18		11	5		17										
	Central Karoo DM: DC5	3	1	11	9	13	6	7	8	4	14	5		12	2		16		18			15		17			
	Garden Route DM: DC4	1	2	8	3	9	12	4	13	6		11		10	5	18	19					20					
	Overberg DM: DC3	1	4	11	5	10	9	2	14	3	17	8		12	7							19					
	West Coast DM: DC1	2	1	11	6	8	12	4	10	5	14			9	3		19		17								

Broad cause
- Comm_mat_peri_nut
- HIV and TB
- Injury
- NCD

(Source: District Health Barometer, South African National Department of Health).

Health-climate change relationships

As mentioned earlier, the health-climate change relationships are described in the following tables (Tables (1-4). The tables show how each aspect of the BoD sub-categories are affected by key climate changes, namely the increase in: Very Hot days, Relative humidity, Extreme precipitation (heavy rainfall events), Flood, Drought and Fire. The relationships between health and climate changes were determined by local epidemiological expertise utilised by this project, rather than specific scientific publications that may pertain to different regions across the world.

Key: Interpreting the table - Example: For Table 1, Burden of Disease, Sub-category: Injury, the table indicates that **Very hot days** (which are projected to increase under climate change) have a significant impact on all aspects of the sub-category of Injury, as seen under the Very Hot days column. The column on the far right, Reasoning, explains the reason for the increase for each aspect of the Injury sub-category.

Table 1. Burden of Disease, Sub-category: Injury

BoD Sub-category	Very Hot days	Relative Humidity	Extreme precipitation days	Flood	Drought	Fire	Reasoning
Interpersonal violence	Significant Increase	No Effect	No Effect	No Effect	Increase	No Effect	Hot and humid conditions can create irritability and stress and lead to aggressive behaviour
Mechanical forces	Significant Increase	Significant Increase	No Effect	No Effect	No Effect	No Effect	Similar conditions can lead to careless working practice and injury
Road injuries	Significant Increase	Significant Increase	Significant Increase	Increase	No Effect	Increase	Similar conditions can lead to careless driving and road crashes
Hanging, strangulation	Significant Increase	Significant Increase	No Effect	No Effect	No Effect	No Effect	Hot and humid conditions can create irritability and stress. It is well known suicides increase during heat waves
Exposure to natural forces	Significant Increase	No Effect	Significant Increase	Increase	No Effect	Increase	Storms could cause injury
Other transport accidents	Significant Increase	No Effect	Significant Increase	No Effect	No Effect	No Effect	Road crash of tankers with toxic loads could cause injury and death

Table 2. Burden of Disease, Sub-category: Major Infectious Diseases, including HIV/AIDS and Tuberculosis

BoD Sub-category	Very Hot days	Relative Humidity	Extreme precipitation days	Flood	Drought	Fire	Reasoning
HIV/Aids	No Effect	No Effect	No Effect	No Effect	Increase	No Effect	Water washed infections could increase
Tuberculosis	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No relationship

Table 3. Burden of Disease, Sub-category: Communicable, Maternal, Perinatal and Nutritional

BoD Sub-category	Very Hot days	Relative Humidity	Extreme precipitation days	Flood	Drought	Fire	Reasoning
Lower respiratory tract Infection	No Effect	No Effect	Increase	Increase	No Effect	Increase	Wet and humid conditions or flood or smoke particulates could aggravate
Diarrhoeal diseases	Significant Increase	Increase	Significant Increase	Significant Increase	Increase	No Effect	High temperatures, humidity and flood will encourage spoiling of food, growth of bacteria, or contamination with waste or faeces
Preterm birth complications	Increase	No Effect	Significant Increase	No Effect	Increase	No Effect	Heat may impact maternal conditions and stress
Septicaemia	Increase	Increase	Significant Increase	Increase	No Effect	No Effect	All except fire could contribute to runaway infections
Meningitis/ encephalitis	No Effect	No Effect	No Effect	No Effect	Increase	No Effect	Typically occurs in cold dry climate conditions
Sepsis/other newborn infections	Significant Increase	Increase	Significant Increase	Increase	Increase	No Effect	As for septicaemia - all except fire could create conditions for infections or aggravate them

Other perinatal conditions	No Effect	No Effect	Significant Increase	Increase	Increase	Increase	As for septicaemia - all except fire could create conditions for infections or aggravate them
Malaria	Significant Increase	Increase	Significant Increase	Increase	No Effect	No Effect	Extreme precipitation and flooding provide extra breeding grounds and along with heat rapid replication of mosquitoes and malaria parasites

Table 4. Burden of Disease, Sub-category: Non-Communicable diseases

BoD Sub-category	Very Hot days	Relative Humidity	Extreme precipitation days	Flood	Drought	Fire	Reasoning
Cardiovascular disease	Significant Increase	Significant Increase	No Effect	Increase	No Effect	Increase	Could cause stroke via stress or aggravate cerebral perfusion insufficiency via drought conditions with dehydration. Also heat exhaustion and heatstroke.
Diabetes mellitus	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No relationship
Hypertensive heart disease	Significant Increase	Significant Increase	No Effect	No Effect	No Effect	No Effect	Could aggravate and reduce cardiac output through venous pooling and dehydration
Ischaemic heart disease	Significant Increase	Significant Increase	No Effect	No Effect	No Effect	No Effect	As for hypertensive heart disease
Endocrine, nutritional, blood, immune system	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No relationship
Chronic obstructive pulmonary disease	Increase	Increase	No Effect	Increase	No Effect	Increase	Aggravate via the work of breathing, growth of mould and fungus in damp/humid conditions and via smoke particulates
Nephritis/ nephrosis	Increase	No Effect	No Effect	No Effect	Increase	No Effect	No relationship
Epilepsy	No Effect	No Effect	Increase	No Effect	Increase	No Effect	No relationship

Asthma	Increase	Increase	Significant Increase	Increase	No Effect	Increase	Hot and humid conditions could promote allergens such as pollens and mouldy fungal growth indoors
Prostate	No Effect	No Effect	No Effect	No Effect	No Effect	No Effect	No relationship

Cause and Effect Pathways: The 1st-to-4th Order Climate Impact Assessment

This section is about understanding climate impacts, as the stakeholders work through the process of elaborating and identifying the impacts that climate change has on a system (i.e. **cause and effect pathways**). The **1st-to-4th Order Climate Impact Assessment Framework** is a participatory tool that helps to deepen people's understanding of climate change vulnerability risk and impacts within communities and amongst decision makers and stakeholders.

Many people from various professions come to climate change stakeholder workshops without an understanding, or at least a vague understanding of how climate change actually affects their area of expertise or interest. In the case of human health, the introductory section dealt with some of those issues as they relate to the health sector. Understanding climate impacts on the health sector is not necessarily straightforward, as most of the health sector's focus is on priority health considerations such as treatments and health services. Additionally, the linkages of climate change to particular socio-economic sectors are generally just not apparent, and stakeholders have often had no previous academic instruction in the matter.

Participants in training and stakeholder workshops find this tool extremely useful. It is also fun, and interesting to work with and assists with commitment to the objectives of the workshops. It usually provokes animated discussion. This may be because a community is a system itself, and the Tool provides a different view of the factors impacting on the community. Overall, this process creates the platform to engage with evidence about how climate change impacts on livelihoods, systems and, in this case, health outcomes.

The goal is to analyse how the impacts of climate change cascade or move through a given system at different time and spatial scales. This section explains how the process unfolds through three steps:

- Link the drivers of risk and vulnerability with local impacts
- Apply a tool to map the causes and effects of climate change in a system, using the 1st-to-4th Order Impact Assessment Framework
- Identify key areas for potential investment to improve climate resilience and/or adaptive capacity.

Key Concepts

Cause and effect pathways

The pathways of the impacts of climate change, as they move through a system. The 1st-to-4th Order Impact Assessment Framework is a useful way to track the path that these occurrences take in a system.

Climate Resilience

The ability of a system and its components to anticipate, absorb, accommodate or recover from the effects of a hazardous event, quickly and efficiently. In other words, the degree to which the system's essential basic structures and functions are able to recover or might improve after the event (adapted from IPCC, 2012: 563).

1st-to-4th Order Impact Assessment Framework

A graphic framework or tool developed by OneWorld. The tool is used to examine how climate changes cascade, or flow through a system, to form various types of impacts: ecosystem, socio-economic, and livelihood impacts (see Figure 3). The Framework allows us to identify potential interventions that can support climate resilience.

Mapping climate change effects on a system

Climate change and its impacts are wide-ranging and climate change generally affects all aspects or levels of a system. This means that climate impacts may begin at one level, or part of the system, and generally flow right through the different elements or levels of that system. A system could be for example the health needs and concerns of an isolated community. Climate change impacts are therefore also felt across different systems and sectors, that additional to human health, include environmental (e.g. air pollution), water,

agriculture and. Because of the cross-cutting nature of climate change, it is critical to use a cross-sectoral approach in climate change assessments.

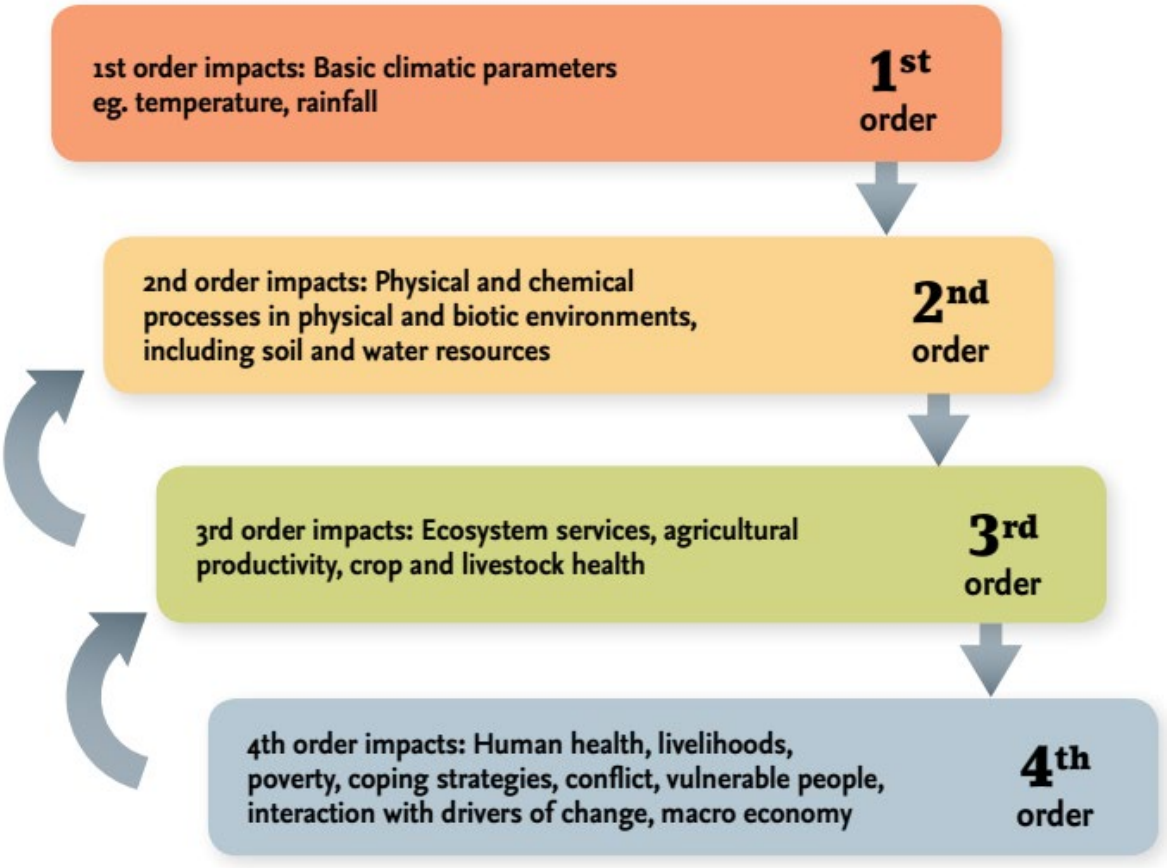
To map this flow of impacts, OneWorld developed the **1st-to-4th Order Climate Change Impact Assessment Framework**, see Figure 3. This tool clearly maps the **cause-and-effect links** that begin with climate effects and move through to impacts on ecosystems, livelihoods and ultimately health outcomes. Thus we can assess the impacts of climate change on multiple components in a chosen system or geography. We can also assess the potential 'feedbacks' or circular effects that exist in a web of interactions (see following sub-section).

Using this tool shows us where vulnerability is concentrated in a system, and what the drivers of vulnerability are. From this we can identify the elements of resilience. This is the first step in identifying in the health tool how climate changes may influence health outcomes as well as responses to strengthen resilience to climate change, in that system.

This view of **cause-and-effect pathways** is very useful in areas with common biophysical and socio-economic systems and drivers. The framework (Figure 3) enables us to clarify the linkages between:

- basic climate parameters (1st order)
- physical and chemical processes in the physical and biotic environment (2nd order)
- ecosystem services and production potential (3rd order), and
- social and economic conditions (4th order).

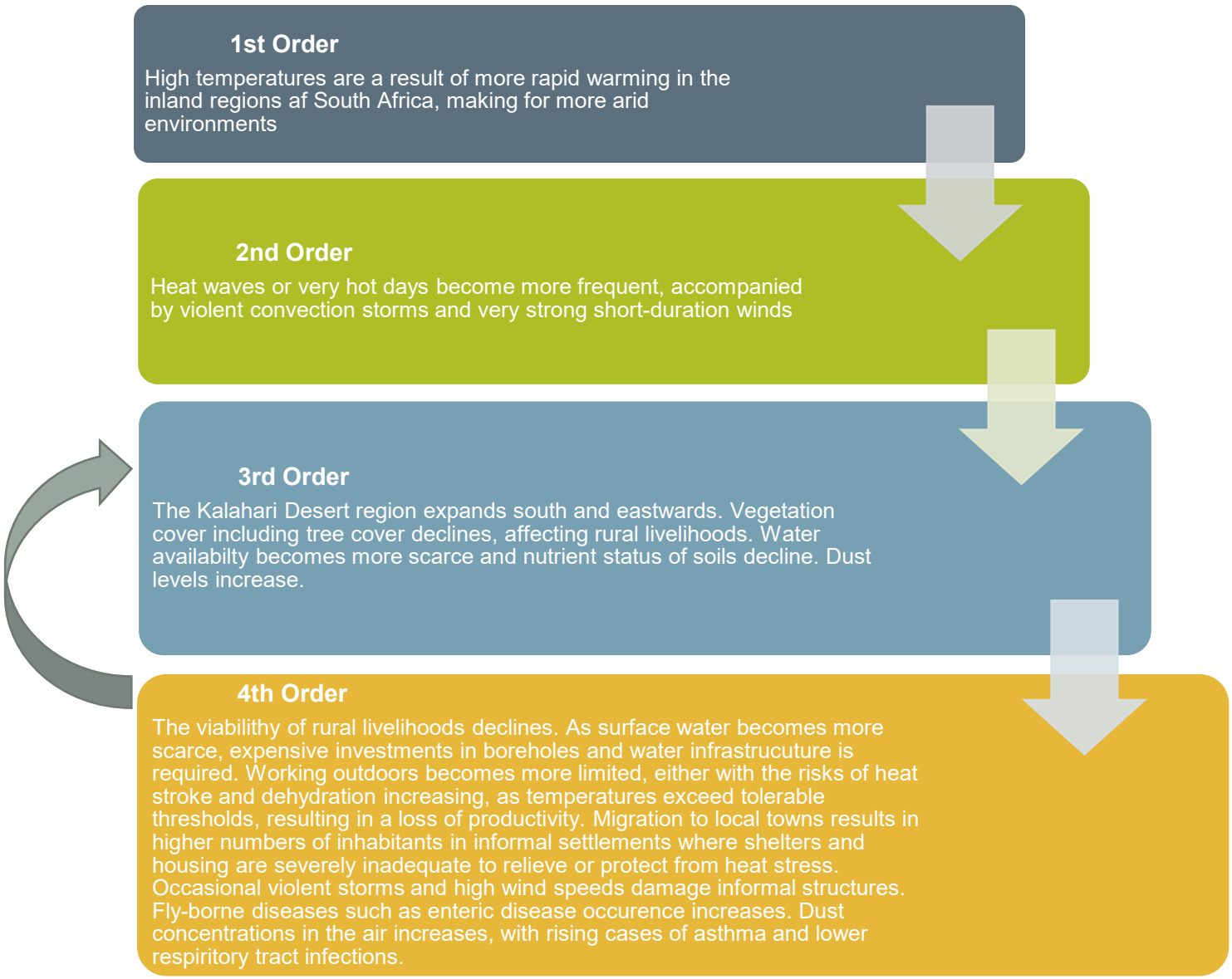
Figure 3: The 1st-to-4th Order Climate Impact Assessment Framework allows us to evaluate the cascading impacts of climate change through a system



Climate change impacts are specific to different contexts

Climate impacts will have varying effects in different regions, provinces or districts. For example, decreased rainfall will impact areas highly dependent on agriculture, to a greater extent than those less dependent on agriculture for income and/or food. This is mainly because of the variability of landscapes and socio-economic systems across different regions. Each area that is seen as highly vulnerable has a unique range of impacts and risks (see the vulnerability maps in Appendix 3). These factors influence our choice of the most appropriate resilience-building responses – or our ability to identify where adaptive capacity needs to be strengthened the most. The figure below (Figure 4) provides an overview of how increased temperatures and aridity (1st order) in South Africa's inland regions, leads to health impacts on people, in the 4th order.

Figure 4. 1st to 4th Order Climate Impact Assessment for the Health Sector, Inland regions of South Africa (indicative)



Feedback loops in a system

It is important to note the role of feedbacks in a system and how the 1st-to-4th Order Impact Assessment Framework accounts for these. Feedbacks are shown as arrows moving upwards on the left of the diagram.

These feedbacks happen mostly as a result of a 4th Order event, such as crop failure due to drought. This would impact for example on ecosystem services (if people then started using more forest resources) or productivity levels, such as reduced yields (3rd Order). However, 4th Order events or interventions can even create feedback impacts higher up in the model as well.

Feedbacks can be positive or negative, for example: if public healthcare access improves (4th Order), people will become healthier. This could increase agricultural productivity or improve land management, and thus improve food security and increase household income (3rd Order). Negative feedback into the system could take place if there was an increased burden of disease, which then reduced agricultural productivity.

Summary of key findings from the District HRVAs

The summary of findings of the HRVA appears as Appendix 3.

As discussed, 52 district level assessments were conducted, using the HRVA tool as revised for this project.

4

Investment and Response Planning

The case for investments into mitigating the impacts of climate change on human health must follow a prioritisation approach. The method here is to first look for patterns of coherency with climate parameters by province and then by district. Recommendations for investment to ameliorate these conditions should not necessarily focus on all sources of morbidity but relatively few, where the investments could be more efficient in gaining the required knowledge, to support interventions. It is likely that active interventions on a few targeted sources of health challenges will impact other aspects of the health challenges because many of them are related in some way.

This section provides the key findings from the HRVA, to support investment and response planning. The findings for each of the health categories (Injury; Major Infectious Diseases; Communicable, Maternal, Perinatal and Nutritional diseases; and Non-communicable diseases and health services) is presented under the relevant headings, with a table denoting the most vulnerable districts, in each category.

In addition, the overall key finding of the HRVA is presented in the box below:

Key finding of the HRVA

A key finding from the HRVA is that there are commonalities in the associations between climate and health in the four categories examined, namely Injury; Major Infectious Diseases; Communicable, Maternal, Perinatal and Nutritional diseases; and Non-communicable diseases.

Injury through inter-personal violence, aggravated by high temperatures and high alcohol consumption and poor diet, which are factors in low-income households, can be related to cardio-vascular disease and hypertension. The districts listed in the tables below, under the various health categories, repeatedly indicate the higher levels of health risk profiles. A limited-budget health investment programme could start by targeting those districts.

Injury

There is a correlation between the temperature patterns across South Africa and the whole risk category of injury. Limpopo, North West Province and Northern Cape are the standout provinces here. Limpopo is of most concern regarding the effects of climate change on the rate of injury. This is possibly also because it is more densely populated and is a border province where there is a high flow of cross-border migrants and travellers. These three provinces are also ranked highest with respect to interpersonal violence, mechanical forces and hanging /strangulation.

The association of interpersonal violence with high temperatures is known as the temperature-aggression theory. There are likely to be other contributing factors to violence that might modify these relationships (Mahendran et al., 2021). There are few literature-based insights about what to do about a temperature-aggression challenge but it is only likely to be solved using research and education/awareness raising. The reasons for higher mechanical force injuries and strangulations in these provinces and districts are not clear, as there is no supporting data, but it is possible that high temperatures may exacerbate the problems.

Recommendation: While this report recommends more research, we suggest here that the DoH and DFFE and other associated government departments (e.g. Labour) take a more pragmatic approach, perhaps using an Occupational Health and Safety (OHS) strategy.

An investment programme could address the following:

- Introduce a programme of education and inspection around mitigating high temperatures in the workplace using an OHS approach. OHS means adopting practices of work which result in lower workplace temperatures. Similarly, address building standards and provide education in how to lower habitation ambient temperatures.
- Develop a research programme on more detailed causative reasons for mechanical force injury and implement a mitigation programme.
- Develop a research programme on the reasons for strangulation and implement a mitigation programme.
- Publish results and conduct monitoring and evaluation on the above.

Table 5. Investment priorities for the health category Injury

Disease category	Districts
Injury	Limpopo - Mopani, Capricorn, Vehmbe, Sekhukhune
	North West - Bojanala, Ngaka Modiri Molema, Segomotsi Mompati
	Northern Cape - John Taolo Gaetsewe, ZF Mgcawu, Pixley Ka Seme District

Major Infectious Diseases

HIV/AIDS and tuberculosis make up the two major infectious diseases here. Epidemiologists do not consider tuberculosis to be sufficiently climate sensitive to warrant climate investment and tuberculosis morbidity is more strongly related to pollution loading in the atmosphere, specifically NO_2, SO_2 and particulate matter PM_{10}. The health level of HIV/AIDS patients is sensitive to a lack of supply of fresh water. HIV/AIDS patients have compromised immune systems and are more vulnerable to any exposure to pathogens than healthy people.

Recommendation: An investment programme would focus on the supply of fresh water to all citizens, which is already a national responsibility and competence, firstly within the domain of the Department of Water and Sanitation and secondly within the domain of the relevant municipality. The DFFE and DoH need to liaise with the DWS to ensure such provision, as well as the Department of Cooperative Governance to ensure the adequate functioning of municipalities, who have the ultimate responsibility for the supply of safe drinking water. Notably, adequate supplies of freshwater will also lead to a reduction in exposure to other infectious pathogens, such as those that cause diarrhoeal diseases.

An investment programme with respect to the major infectious diseases (above what is already being spent on these priority diseases in South Africa) could address the following:

- Monitoring and evaluation of progress and maintenance of the supply of safe drinking water to all, nationally.
- Develop a research programme on the effects of temperature rises or any other climatic influences on the prevalence or infectiousness of tuberculosis, which is not well understood at present, despite a few publications.

Table 6 Investment priorities for the health category Major infectious diseases

Disease category	Districts
HIV/AIDS	The programme should be implemented across the country

Communicable, Maternal, Perinatal and Nutritional diseases

Diarrhoeal diseases are the greatest health risk in this health category. All provinces have high diarrhoeal risk counts. It is the second leading cause of deaths and malnutrition in children under the age of five, according to WHO. The disease has a clear link to higher temperatures. A significant proportion of diarrhoeal disease can be prevented by the provision of safe drinking water and adequate sanitation and hygiene. Diarrhoeal pathogens are mostly spread by faeces-contaminated water, and there is a faster spread of diarrhoeal disease pathogens during the warmer months. This could be associated with higher densities of vectors such as the common house fly *Musca domestica* and the latrine fly *Chrysomya putoria*, both known to be carriers of enteric pathogens. ***Inadequate supplies of safe drinking water, inadequate sanitation and poor hygiene are prevalent in informal settlements.***

Septicaemia can be lumped together with sepsis and other new-born infections, as particular climate-change exacerbated health challenges, because they have similar origins. These afflictions more commonly occur in low health care resource settings and are partially a result of compromised immune systems (e.g. HIV/AIDS). Infections with diarrhoeal disease also result in increased susceptibility to septicaemia (see above). Common factors here are personal hygiene and access to clean water. As noted earlier, the high prevalence of HIV/AIDS in South Africa, diarrhoeal diseases, septicaemia and sepsis all have some commonality in terms of prevention – for example improved WASH.

Recommendations: An investment programme could target the following:

- The high incidence of diarrhoeal disease requires investments into a programme that focuses on the delivery of safe drinking water, maintenance of water infrastructure, investments in better sanitation and developing education and awareness programmes around hygiene. This is the standard WHO WASH programme, which builds on achieving the goals of sustainable development goal SDG 6: "Clean water and sanitation for all". There is sufficient information in those programmes to establish an effective monitoring and evaluation programme.
- An investment in combating septicaemia and sepsis should include further research on causes in the districts specified, as well as focusing on implementing WASH programmes.

Table 7. Investment priorities for the health category Communicable, Maternal, Perinatal and Nutritional diseases

Disease category	Districts
Diarrhoeal diseases	The programme should be implemented across the country. However, a focus for investment towards reducing the case load of diarrhoeal disease could focus on these districts first: Mopani and Sekhukune (Limpopo); Sedibeng and City of Johannesburg (Gauteng); Thabo Mofutsanyane and Fezile Dabi (Free State).
Septicaemia and related diseases	Limpopo - Mopani District, Vehmbe
	North West – Bojanala platinum, Ngaka Modiri Molema
	Gauteng – City of Johannesburg, Sedibeng
	Free State – Fezile Dabi, Thabo Mofutsanyane
	KwaZulu Natal - Ugu

Non-communicable diseases

Cardiovascular disease (CVD) is ameliorated by climate parameters: changes including higher temperatures and increased humidity result in higher incidences of CVD causing strokes via stress or by aggravated cerebral perfusion insufficiency. This happens as a result of inadequate hydration, along with heat exhaustion

and heat stroke. Again, we see from the ranking by provinces that Limpopo, North West and Northern Cape are the three most affected by CVD risks. This relationship also holds with hypertensive heart disease and ischaemic heart disease. This cluster correlates with the hottest provinces, which are also most likely to be further affected by temperature increases as a result of GHG-induced climate changes.

Some of the factors that create the vulnerability of CVD, hypertensive and ischaemic heart disease relate to socio-economic conditions in South Africa. This includes factors such as inadequate diet, in which excessive amounts of simple carbohydrates are ingested – sugared products and drinks, maize and processed wheat products, excessive salt in foods (fast foods, salted crisps and similar) and high alcohol consumption. Notably, South Africa has the 5th highest consumption of alcohol per capita in the world, even though many are abstemious – more than 60% (World Health Organisation, 2018). This is despite the fact that colder, darker climates are more associated with high alcohol consumption. Six percent of women in the Northern Cape have a drinking problem and consume more than double the national average alcohol amount.

Recommendation: An investment programme could target the following:

- An investment programme in education around factors to manage for CVD, hypertensive and ischaemic heart disease, managing for the following:
    - Restricting salt intake, increased intake of vegetable fibre in personal diets (dietary education), reducing intakes of saturated fats, weight control, regular exercise, moderate to reduced alcohol consumption and quitting smoking.

Table 8. Investment priorities for the health category Non-Communicable Diseases

Disease category	Districts
CVD, ischaemic and hypertensive heart diseases	Limpopo - Mopani, Capricorn, Vehmbe, Sekhukhune
	North West - Bojanala, Ngaka Modiri Molema, Segomotsi Mompati
	Northern Cape - John Taolo Gaetsewe, ZF Mgcawu, Pixley Ka Seme District
	Gauteng – City of Johannesburg

Health Services

Climate change, through the mechanism of extreme weather – very heavy rainfall, flooding and high temperatures mitigate against access to health services, and once there, the patient requires the service for the climate-related disease or injury.

Recommendations: An investment programme could target the following:

- Health services are required to have specific treatment plans and capacity to treat patients in the four categories of disease above, as well as these additional districts, which are more vulnerable to other aspects of climate change such as flooding, high-intensity storms, which can prevent access to health facilities and/or cause physical challenges to the patient, and air quality problems, which can be exacerbated by high temperatures.

Table 9. Investment priorities for the health category Health Services

Service category	Treatment category	Districts
Ambulatory	Chronic care - communicable disease; mental; non-communicable	OR Tambo (Eastern Cape), Fezile Dabi (Free State), Thabo Mofutsanyane (Free State),

	Preventative, promotive	Thabo Mofutsanyane (Free State), eThekwini Metro (KwaZulu Natal), ZF Mgcawu (Northern Cape).
	Acute curative - minor ailments including diarrhoea, malaria, minor trauma	Fezile Dabi (Free State), Bojanala Platinum (North West), Thabo Mofutsanyane (Free State), Ilembe (KwaZulu Natal), Mopani District (Limpopo), uMgungundlovu (KwaZulu Natal), Nkangala (Mpumalanga)
Community	Environmental health services (air pollution)	Sedibeng (Gauteng), OR Tambo (Eastern Cape), eThekwini (KwaZulu Natal)
	Community services and health promotion	OR Tambo (Eastern Cape), eThekwini (KwaZulu Natal), Fezile Dabi (Free State)
	Programmes – malaria and others	Others - OR Tambo (Eastern Cape), Fezile Dabi and Thabo Mofutsanyane (Free State), Sedibeng
Hospital casualty, inpatient, specialist ambulatory services	Casualty	OR Tambo (Eastern Cape)
	Obstetrics	OR Tambo (Eastern Cape)
	Surgery & orthopaedic – acute; elective	OR Tambo (Eastern Cape)
	Medical	OR Tambo (Eastern Cape)
	Paediatric	OR Tambo (Eastern Cape)
	Obstructive pulmonary disease	Sedibeng (Gauteng)
	Ambulance referrals, transport	ZF Mgcawu District (Northern Cape)
Support Services	Clinical e.g. Laboratory, Radiology, Pharmacy	Fezile Dabi and Thabo Mofutsanyane (Free State), OR Tambo (Eastern Cape)
	Allied medical	City of Ekhuruleni, City of Johannesburg
	IT, HIS and Tele-medicine	OR Tambo (Eastern Cape), Fezile Dabi and Thabo Mofutsanyane (Free State),
	Non-clinical - support services	City of Johannesburg (Gauteng), Mopani District (Limpopo)
	Infection control, occupational health & safety	Pixley Ka Seme (Northern Cape), Bojanala Platinum District and Ngaka Modiri Molema District (North West)

5

Concluding Remarks

The impacts of climate change are already being felt, not least in South Africa's health sector, and are set to become more severe. Climate change is impeding the country's opportunities for achieving important developmental targets, in health, in provision of clean water and sanitation and hygiene (WASH), as well as others such as education. Like climate change, health is cross-cutting – when health targets are not met, other targets become more difficult to attain, affecting productivity, employment rates, maternal health and early childhood development, amongst others.

The HRVA carried out under this study provided a critical opportunity, not only to update the HRVA Tool, but to engage stakeholders in the sector, around the nexus of climate change, health and livelihoods. The deep engagement of the stakeholders during the workshops suggests that their commitment to addressing the additional challenge of climate change in the sector, will be sustained.

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Appendix 1: Tool Methodology and Data

Three main datasets were utilised in the Tool's modelling of the risk of a health hazard due to climate change, namely: relevant climate change data, health officials' estimates of future severity of BoD and health services, and the table of interactions between climate change exposures (CCEs) and BoD, and health services. One secondary dataset was used to inform health officials of the current BoD data in South Africa.

Climate Change Data

The main climate change dataset used was the Council for Scientific and Industrial Research's (CSIR's) Greenbook data, which was developed by the CSIR for public and government officials to have access to quantitative data of the likely impacts of climate change and urbanisation in South Africa (CSIR, 2019). The data is mapped spatially at the municipal level and with district markers, and as such was used to build the climate change dataset. This was supplemented by data from the Climate Research Unit's Time Series data, which is a global gridded timeseries climate change dataset (Harris, 2021), with the overall climate change dataset developed by Arthur Chapman for the project. This was supplemented by flood, and fire data mapped, and modelled by Rob Davies of Habitat INFO, using climate change datasets developed by OneWorld.

Out of the four Representative Concentration Pathways (RCPs), RCP 8.5 was selected. The RCPs are a series of four greenhouse gas concentration trajectories utilised by the Intergovernmental Panel on Climate Change (IPCC) to make projections based on anthropogenic greenhouse gas (GHG) emissions (IPCC, 2014). RCP 2.6 represents stringent mitigation of GHG, RCP 4.5 and 6.0 represent intermediate mitigation, while RCP 8.5 represents unmitigated GHG which continues to rise throughout the 21st century (IPCC, 2014; Davis-Reddy & Vincent, 2017). RCP 8.5 was selected as it offers a 'no regrets' option to modelling, as modelling the lower RCP levels may result in overly optimistic projections and an under-prepared health sector.

The climate change exposure (CCE) data from the municipalities forming the districts were averaged to form district CCE values. This was done for the number of very hot days (days where temperature exceeds 35°C), extreme precipitation days (where precipitation exceeds 20mm), relative humidity, floods, drought, and fire. These CCEs were selected as they are the most common CCEs which impact BoD, and because very hot days, extreme precipitation days, and relative humidity form the three basic CCEs that the World Health Organisation (WHO) recommends for all HRVAs (WHO, 2013). The CCEs are probabilistic projections of future climate events, and by separating the data into quartiles it is possible to then give a probability of occurrence to each of the districts for their specific CCEs relative to the national CCE dataset.

The probabilities approach, and the probabilities which were assigned were developed by Professor Jonny Myers. As such the risk of a health impact due to CCEs should be considered a relative risk, as the risk factor is compared relative to national CCE values, and thus risk values should be understood as showing the risk to a district's BoD (or health service, sub-category), **relative to other districts**.

District Health Officials' Estimates of Future Severity of BoD, and Health Services

District health officials' estimates of future severity of BoD, and health services in the 2020 to 2050 period were captured by assigning severity rankings for the BoD and for health services sub-categories, during a series of HVRA Workshops (see Table 10 and Table 11). District health officials were asked to consider their district's socio-economic circumstances, population changes, and the impact of climate change on each sub-category of BoD and health services and to assign a severity rank to represent how better or worse they expect a sub-category to be for the 2020-2050 period. The severity ranking has five levels: Very Low, Low, Medium, High, and Very High.

To ensure a balanced opinion, severity rankings were assigned by a group of district health officials representing different areas of health expertise who discuss each sub-category before assigning a severity

rank. Each district nominates a 'champion' or 'scribe', who was tasked with leading the group discussions and inputting the severity ranks. The scribes were identified by the districts and were individuals who showed a willingness to contribute to discussions and who interrogated the topic deeply. While some of the scribes did have a better knowledge of climate change than other district health officials, this was not a requirement for selection, as the primary characteristic was willingness to share knowledge and to engage with the material.

The decision to select a scribe to lead the assigning of severity rankings was based on the literature on communities of practice (CoPs), particularly those held in an online setting. In CoPs a champion (which the scribe filled the role of) is critical for engaging non-participating members and driving discussions by leading the sharing of knowledge (Hew & Hara, 2006; Barret et al, 2009; Britt & Paulus, 2016). CoPs which hold facilitated and led discussions tend to have a higher level of engagement, sharing of knowledge, and a higher quality to discussions than free-form discussions (Britt & Paulus, 2016). As such a scribe would ensure that the maximum amount of data would be captured, and that it would be of higher quality. This has the further benefit of continuing to build ownership of the Tool by district health officials, which is a critical component for ensuring that it continues to be used and applied after the projects end, and also increases the level of engagement in the Tool by district health officials (World Bank, 2018; Petrie et al., 2021).

Table 10. Summary of Risk and Vulnerability Assessment Workshops

Province	Date & time	Status
Gauteng	Mon, 15 Nov, 9h30 – 12h30	Completed
Eastern Cape	Mon, 22 Nov to Weds, 24 Nov, 9h30 – 12h30	Completed
KwaZulu-Natal	Mon, 29 Nov to Weds, 1 Dec, 09h30 – 12h30	Completed

Table 11. Summary of Full Day Capacity Building and Risk and Vulnerability Assessment Workshops

Province	Date & time	Status
Western Cape	Weds, 17 Nov, 9h30 – 16h30	Completed
Limpopo	Thurs, 18 Nov, 9h30 – 16h30	Completed
Free State	Tues, 23 Nov, 9h30 – 16h30	Completed
North West	Wed, 24 Nov, 9h30 – 16h30	Completed
Northern Cape	Thur, 25 Nov, 9h30 – 16h30	Completed
Mpumalanga	Mon, 29 Oct, 9h30 – 16h30	Completed

Table of Climate Change Exposure and BoD and Health Services interaction

Finally, a table of interactions between the CCEs and BoD sub-categories was developed. As noted previously, there has been no attempt to develop a consolidated list of interactions between CCEs and BoD in South Africa, however an extensive body of work looking at individual diseases exists – although none give definitive, quantitative interactions. Thus, based on the literature, a table of interactions between CCEs and BoD (Table 12), and between CCEs and health services (Table 13) sub-categories was developed by the project team's two health experts, Professor Jonny Myers, Dr Anthony Kinghorn, and climate change adaptation expert Arthur Chapman to inform the Tool's risk model.

The Interaction Table uses a simple method of ranking the interaction between CCEs and sub-categories, with ranks of zero (no effect), one (increase), or two (significant increase). This then allowed for the district health officials' severity estimates and CCE data to be modelled to estimate the probable relationship between the two datasets. There is no recognised or formalised quantitative ranking on which these interactions could be based, and as such is a quantitative representation of qualitative knowledge.

Table 12. Table of Interactions between Climate Change Exposures and Burden of Disease Sub-categories

	Extreme precipitation days	Very Hot days	Relative Humidity	Flood	Drought	Fire
HIV/Aids	0	0	0	0	1	0
Tuberculosis	0	0	0	0	0	0
Lower respiratory tract Infection	1	0	0	1	0	1
Diarrhoeal diseases	2	2	1	2	1	
Preterm birth complications	2	1	0	0	1	0
Septicaemia	2	1	1	1	0	0
Meningitis/encephalitis	0	0	0	0	1	0
Sepsis/other newborn infections	2	2	1	1	1	0
Other perinatal conditions	2	0	0	1	1	1
Malaria	2	2	1	1		
Cardiovascular disease	0	2	2	1	0	1
Diabetes mellitus	0	0	0	0	0	0
Hypertensive heart disease	0	2	2	0	0	0
Ischaemic heart disease	0	2	2	0	0	0
Endocrine, nutritional, blood, immune system	0	0	0	0	0	0
Chronic obstructive pulmonary disease	0	1	1	1	0	1
Nephritis/nephrosis	0	1	0	0	1	0
Epilepsy	1	0	0	0	1	0
Asthma	2	1	1	1		1
Prostate	0	0	0	0	0	0
Interpersonal violence	0	2	0	0	1	0
Mechanical forces	0	2	2	0	0	0
Road injuries	2	2	2	1	0	1
Hanging, strangulation	0	2	2	0	0	0
Exposure to natural forces	2	2	0	1	0	1

Other transport accidents	2	2	0	0	0	0

Table 13. Table of Interactions between Climate Change Exposures and Health Services

	Extreme precipi-tation days	Very Hot days	Relative Humidity	Flood	Drought	Fire
Acute curative - minor ailments incl diarrhoea, malaria, minor trauma etc	1	1	0	1	1	1
Preventive, promotive	2	1	0	2	1	1
Chronic care - communicable disease; mental; non-communicable	2	1	0	2	0	1
Environmental health services	2	1	0	2	1	0
Community services & health promotion	2	1	0	2	1	1
Malaria or other specific programs	2	0	0	2		0
Casualty	1	1	0	2	1	2
Obstetrics and Gynae	0	0	0	2	0	1
Surgery & orthopaedic – acute; elective	1	0	0	2	0	1
Medical	1	1	0	2	1	1
Paediatric	2	0	0	2	1	1
OPD	1	1		1	1	1
Ambulance, referrals, transport	1	1	0	2	0	1
Clinical e.g. Laboratory, Radiology, Pharmacy	1	1	0	1	0	1
Allied medical	0	0	0	1	1	1
IT, HIS and Tele-medicine	1	0	0	1	0	0
Non-clinical - support services	1	1	1	1	1	1
Infection control, occupational health & safety	2	2	0	0	0	2

Baseline BoD data

A secondary dataset which was not used in the Tool's risk modelling - but was displayed in the Tool - was the baseline, or current, BoD data. This dataset provided district health officials with current BoD as a baseline for their estimates of future severity and was sourced from the Health Systems Trust District Health Barometer (DHB) 2019/2020 data (Health Systems Trust, 2020). Unfortunately, the same data was not

available for health services to provide a baseline for district health officials. This data was given to district health officials to aid in their estimates of future severity by providing a baseline which they could compare against.

Baseline BoD was established using two sets of data from the DHB. Firstly, the years of life lost by percentage for the four main categories of BoD by district from the year 2017 (the latest available), which was displayed to district health officials as a graph in the Tool's Climate Change and Health Context sheet. Secondly, the DHB ranking of each of the top 26 diseases in South Africa for each district as of 2020 was used (Massyn et al., 2020). This ranks BoD from 1 (most significant contributor to BoD) to 20 (least significant contributor to BoD) and was used to indicate the current severity of each sub-category. The scale was reversed for easier interpretation when represented graphically, as follows:

$$\textbf{\textit{BoD ranking = 21-X}}$$

Thus, the most significant health impacts have a higher numerical value, beginning ranking at zero for no data and then scaling upwards to 20 for the highest rank. The sub-categories then had their quintiles determined. Quintile rankings of districts' sub-categories of BoD allows district health officials to compare their district's current severity of BoD to the national dataset as a point of reference when making their estimates of future severity of BoD. The data was displayed to district health officials in each of the relevant BoD Dashboard sheets in the Tool, first as a graph of the raw values, and then as tables of the quintile data.

How the Tool Calculates the Relative Risk of a Health Hazard due to Climate Change

The Tool uses the three main datasets to provide an estimate of the probable risk of a health hazard resulting from climate change. As such this is the risk that climate change will increase the number of cases of a given disease, increase the severity of the disease in individuals already suffering from it, or result in both these outcomes. For health services this means that there will be increased difficulty in providing a given health service, an increase in the demand for the health service, or both outcomes occurring. For example, extreme precipitation days, very hot days, flood, drought, and fire all negatively impact casualty services, which will both experience an increased demand for casualty health services due to these CCEs, but also increased difficulty in providing casualty services due to possible damage to healthcare infrastructure.

The Tool calculates a district's risk values by multiplying each of the district's CCEs by its relative interaction terms for the sub-category, which are then summed and divided by the number of non-zero CCEs after multiplication by their interaction term, to get an average CCE value, which is then multiplied by the severity rank assigned by the district health officials. Importantly the equation only averages the non-zero CCE values which ensures that the risk values are not biased towards sub-categories which have less than six non-zero interaction terms. If not, a sub-category such as interpersonal violence which has the interaction terms of two for very hot days, and one for drought, but zero for extreme precipitation days, relative humidity, flood, and fire, would have a significantly lower risk value even if it is anticipated as being at significant risk given climate change. The interaction terms ensure that CCEs which have no effect on the sub-category are excluded, while CCEs which result in a significant increase in the sub-category are doubled, this as the scale utilised is zero (no effect), one (increase), and two (significant increase).

To calculate this the Tool utilises the following equation to calculate potential risk:

$$Potential\ of\ Health\ Impact\ Risk = SF * \frac{(CCE_1 * CCEi_1) + (CCE_2 * CCEi_2) + \cdots + (CCE_n * CCEi_n)}{NNZCCE}$$

CCE_1: Climate Change Exposure 1

$CCEi_1$: Climate Change Exposure 1 Interaction Term

NNZCCE: Number of Non-Zero Climate Change Exposure with Interaction Terms

As such with the current CCEs data used results in the following equation:

$$Potential\ of\ Health\ Impact\ Risk = SF * \frac{(VHD * VHDi) + (EPD * EPDi) + (RH\ * RHi) + (D * Di) + (FL * FLi) + (FI * FIi)}{NNZCCE}$$

SF: Severity Factor

VHD: Very Hot Days

VHDi: Very Hot Days interaction term

EPD: Extreme Precipitation Days

EPDi: Extreme Precipitation Days interaction term

RH: Relative Humidity

RHi: Relative Humidity interaction term

FL: Flood

FLi: Flood interaction term

FI: Fire

FIi: Fire interaction Term

Example

For example, looking at exposure to natural forces for the Amajuba district in KwaZulu-Natal, with a severity rank of Very High, the equation would produce the following results:

$$Potential\ of\ Health\ Impact\ Risk = SF * \frac{(VHD * VHDi) + (EPD * EPDi) + (RH\ * RHi) + (D * Di) + (FL * FLi) + (FI * FIi)}{NZCCE}$$

$$Potential\ of\ Health\ Impact\ Risk = 5 * \frac{(1 * 2) + (3 * 0) + (0.1\ * 0) + (1 * 1) + (3 * 0) + (3 * 0)}{NZCCE}$$

$$Potential\ of\ Health\ Impact\ Risk = 5 * \frac{(2) + (0) + (0) + (1) + (0) + (0)}{2}$$

$$Potential\ of\ Health\ Impact\ Risk = 5 * 1.5$$

$$Potential\ of\ Health\ Impact\ Risk = 7.5$$

The resulting risk values are numeric values that hold no meaning for district health officials, and are therefore converted into text-based results, which utilise the matrix shown in

Table 14. Note that

Table 14 displays the matrix with both an interaction term of one and two, as the likelihood of CCEs with an interaction term of one are 0.3, 1, 3, and 10:

Table 14. Probability of Climate Change Exposure Multiplied by Severity Ranking Matrix to Form a Risk Matrix

Severity Factor	Probability of CC Event							
	0.3	0.6	1	2	3	6	10	20
1	0.3	0.6	1	2	3	6	10	20
2	0.6	1.2	2	4	6	12	20	40
3	0.9	1.8	3	6	9	18	30	60
4	1.2	2.4	4	8	12	24	40	80
5	1.5	3	5	10	15	30	50	100

Probability of CC Event

Severity Factor	0.3	0.6	1	2	3	6	10	20
1	Very Low	Very Low	Very Low	Low	Medium Low	Medium	Medium High	Medium High
2	Very Low	Low	Low	Medium Low	Medium	Medium High	Medium High	High
3	Very Low	Low	Medium Low	Medium	Medium	Medium High	High	Very High
4	Low	Medium Low	Medium Low	Medium	Medium High	High	High	Very High
5	Low	Medium Low	Medium	Medium High	Medium High	High	Very High	Very High

Risk Matrix

The bands of values which each risk category falls into were selected by setting upper and lower bounds which would allow for a gradient increase in the values which followed the interactions within the matrix. The Risk Matrix is used as the reference point for the Tool, which converts the numerical risk values to text values, which are then displayed to district health officials and used to populate the Combined risk Rankings for all Districts in the various BoD Dashboards, and the Health Services Dashboard.

As such the Tool considers all the relevant CCEs which impact a given disease or health service when calculating each district's risk values by utilising the Table of Interactions, and ensures that the risk values are a reflection of a spectrum of CCE impacts on health. As such the connection between the CCE values and risk values can be clearly seen when comparing the CCE maps and the maps of the risk values shown in Appendix 2 to this report.

Appendix 2: Summary of findings

This Appendix presents the overall summary findings of the study, presented by BoD sub category.

Injury

Table 15. National relative risk values

	Interpersonal violence	Mechanical forces	Road injuries	Hanging, strangulation	Exposure to natural forces	Other transport accidents
National Minimum	1	0	3	1	0	0
National Q2	6	3	15	4	14	11
National median	13	16	24	14	22	16
National Q3	30	35	35	39	35	35
National Maximum	75	100	56	80	48	55

Table 16. Ranking of provinces by average relative risk rankings

	Interpersonal violence	Mechanical forces	Road injuries	Hanging, strangulation	Exposure to natural forces	Other transport accidents
1	Limpopo	Limpopo	Limpopo	Limpopo	Free State	Limpopo
2	Northern Cape	Northern Cape	North West	North West	Limpopo	Free State
3	North West	North West	Free State	Northern Cape	North West	Northern Cape
4	Gauteng	Gauteng	Northern Cape	Western Cape	Northern Cape	North West
5	Mpumalanga	Western Cape	Gauteng	Gauteng	KwaZulu Natal	Gauteng
6	KwaZulu Natal	Mpumalanga	Mpumalanga	Mpumalanga	Gauteng	Eastern Cape
7	Free State	Free State	Western Cape	Free State	Mpumalanga	KwaZulu Natal
8	Western Cape	KwaZulu Natal	KwaZulu Natal	KwaZulu Natal	Eastern Cape	Mpumalanga
9	Eastern Cape	Eastern Cape	Eastern Cape	Eastern Cape	Western Cape	Western Cape

Table 17 lists the districts which have the top 5 relative risk values for each of the Injury sub-categories.

Table 17. Ranking of Districts by Relative Risk Ranking

	Interpersonal violence	Mechanical forces	Road injuries	Hanging, strangulation	Exposure to natural forces	Other transport accidents
1	Mopani District (Limpopo)	Mopani District (Limpopo)	Mopani District (Limpopo)	Capricorn District (Limpopo)	Fezile Dabi District (Free State)	Sedibeng District (Gauteng) Waterberg District (Limpopo)
2	Bojanala Platinum District (North West)	Capricorn District (Limpopo) Sekhukhune District (Limpopo) John Taolo Gaetsewe District (Northern Cape)	Sekhukhune District (Limpopo)	Vhembe District (Limpopo) Sekhukhune District (Limpopo) John Taolo Gaetsewe District (Northern Cape)	Thabo Mofutsanyane District (Free State) Sedibeng District (Gauteng) ZF Mgcawu District (Northern Cape)	Fezile Dabi District (Free State) Mangaung Metro District (Free State)
3	Pixley Ka Seme District (Northern Cape)	King Cetshwayo District (KwaZulu Natal) Bojanala Platinum District (North West)	Capricorn District (Limpopo)	Bojanala Platinum District (North West) Ngaka Modiri Molema District (North West)	Mopani District (Limpopo)	OR Tambo District (Eastern Cape) Sekhukhune District (Limpopo)
4	Waterberg District (Limpopo) Sekhukhune District (Limpopo) Frances Baard District (Northern Cape)	West Rand District (Gauteng)	City of Johannesburg Metro District (Gauteng)	Waterberg District (Limpopo)	eThekwini Metro District (KwaZulu Natal)	Thabo Mofutsanyane District (Free State) Mopani District (Limpopo) Vhembe District (Limpopo)
5	Namakwa District (Northern Cape) Ngaka Modiri Molema District (North West)	Ngaka Modiri Molema District (North West)	Vhembe District (Limpopo)	King Cetshwayo District (KwaZulu Natal) Dr. Ruth Segomotsi Mompati District (North West)	Alfred Nzo District (Eastern Cape) Ugu District (KwaZulu Natal) Bojanala Platinum District (North West) Ngaka Modiri Molema District (North West)	Ugu District (KwaZulu Natal)

Ranking of Injury Sub-categories:

Note that ranking is based on a count of districts top ranked diseases, as such this does not compare the magnitude of the values between the provinces, but counts how many times district officials ranked a sub-category's relative risk value as 1st, 2nd, 3rd etc. in the district. Further, note that the count of the number of times a sub-category appears in a rank is listed in brackets.

Table 18. Summarised Injury Sub-Categories Ranking by Count of District Rankings

Rank:	Diseases (number of districts):
1st	Other Transport Accidents (13), Exposure to natural forces (12), hanging and strangulation (10)
2nd	Road Injuries (21)
3rd	Mechanical forces (7)
4th	Interpersonal violence (17)

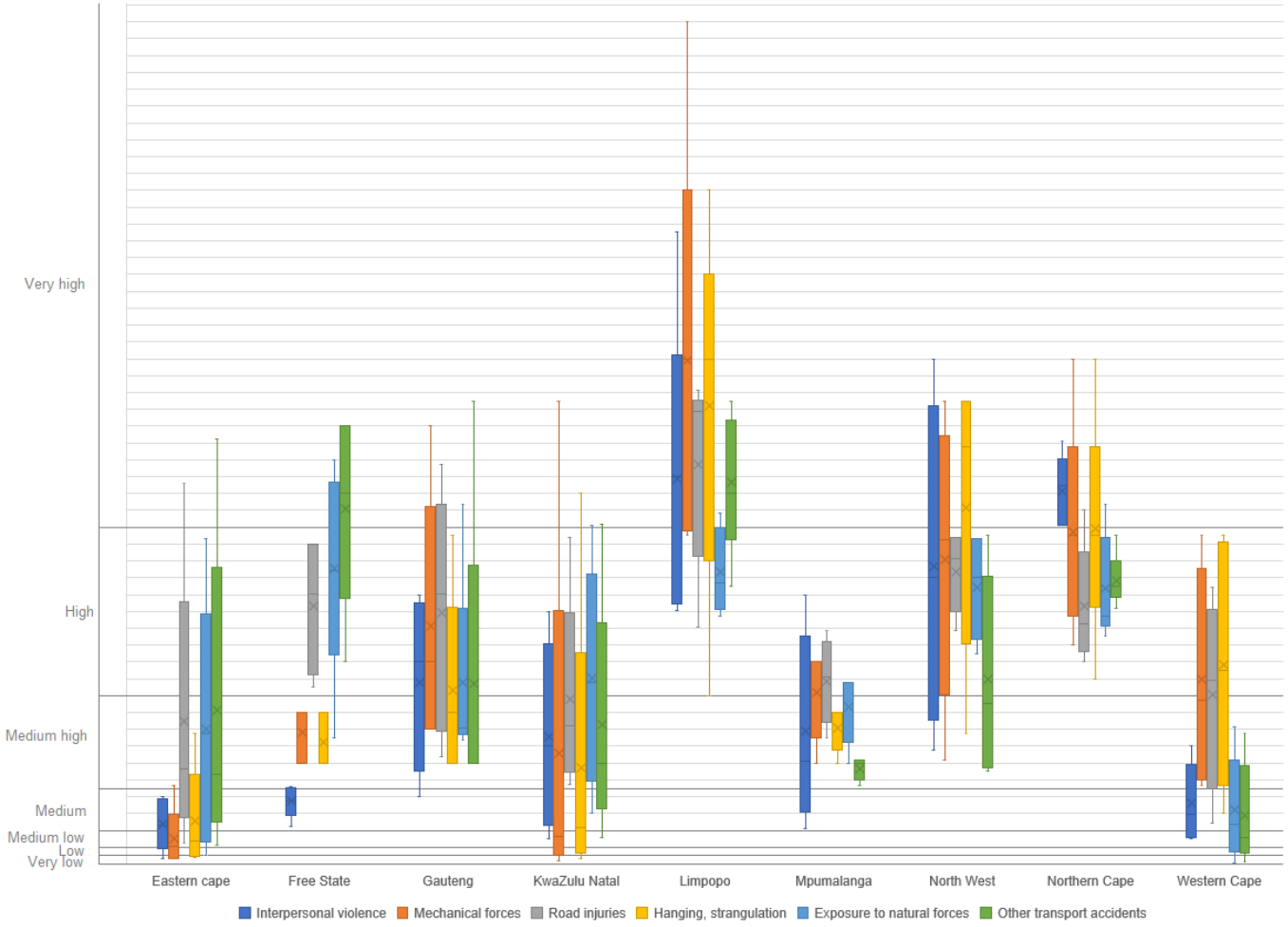
Table 19 below gives the full list of sub-categories count for comparison sake.

Table 19. Full Injury Sub-Categories Ranking by Count of District Rankings

Province Top 5 Count:	1	2	3	4	5	6
Interpersonal violence	9	4	5	17	13	4
Mechanical forces	7	12	7	6	11	9
Road injuries	6	21	17	1	4	3
Hanging, strangulation	10	8	6	10	14	4
Exposure to natural forces	12	10	5	9	8	8
Other transport accidents	13	6	10	8	5	10

Figure 5 below gives the minimum, quartile two, median, quartile three, and maximum risk values for the sub-categories of disease by province.

Figure 5. Box and Whisker Graph of the Injury Category



The following table gives key findings per sub-category of Injury.

Table 20. Key findings per sub-category of Injury

Disease	Convergent	Divergent
Interpersonal violence	4th ranked sub-category of disease in EC, KZN, NW, and WC. National relative risk values are clustered between medium and high relative risk ranks, with medium (31%), medium high (13%), high (23%), and very high (19%). Thus, while lower in the relative risk values ranking in Table 18, interpersonal violence has elevated relative risk ranks in most provinces.	NC has a significantly higher ranking for interpersonal violence than other Injury sub-categories, when compared to other provinces. 3rd ranked sub-category of disease in MP. EC, and FS interpersonal violence relative risk values are lower that other sub-categories of disease, in comparison to the difference in sub-categories seen in other provinces. This difference is the most pronounced in the FS.
Mechanical forces	3rd ranked sub-category of disease in NW, and WC, but 2nd ranked in MP, NC, and GP. Relative risk tanks are clustered between medium high, to high, with medium high (27%), high (27%), and very high (15%).	EC, and FS mechanical forces relative risk values are lower that other sub-categories of disease, in comparison to the difference in sub-categories seen in other provinces. KZN has the largest distribution of relative risk ranks, ranging from very high to very low.

Road injuries	2nd ranked sub-category of disease in EC, KZN, LIM, NW, and WC. From Figure 5 it can be seen that the road injuries values across the provinces are comparatively similar. Road injuries relative risk ranks are clustered between medium high and very high, with medium high (33%), high (48%), and very high (13%).	NC is the main exception, where road injury values are ranked lower when compared to other provinces.
Hanging, strangulation	Top ranked sub-category of disease in LIM, NW, and WC. Relative risk ranks are clustered around medium high, with medium (12%), medium high (35%), high (17%), and very high (17%).	EC, FS, and MP have significantly lower relative risk values than other sub-categories in the province, when compared to other provinces.
Exposure to natural forces	Top ranked sub-category of disease in KZN, and 2nd top ranked sub-category of disease in the EC, and FS. Relative risk values are clustered around high, with medium high (25%), high (48%), and very high (12%).	WC is the outlier, with significantly lower relative risk values than other sub-categories in the province, when compared to other provinces.
Other transport accidents	Top ranked disease category in EC, FS, and for three districts in KZN. In all other provinces other transport accidents ranks far lower. Relative risk ranks are clustered around high, with medium high (42%), high (23%), and very high (19%).	MP, and WC are the outlier significantly lower relative risk values than other sub-categories in the province, when compared to other provinces.

Major Infectious Diseases

As there are no interactions between tuberculosis, and the climate change exposures in the Tool, and as such there are no relative risk values for tuberculosis, while the impact on HIV/Aids is limited to the impact of drought.

Table 21. National relative risk values

	HIV/Aids
National Minimum	0
National Q2	2
National median	5
National Q3	13
National Maximum	40

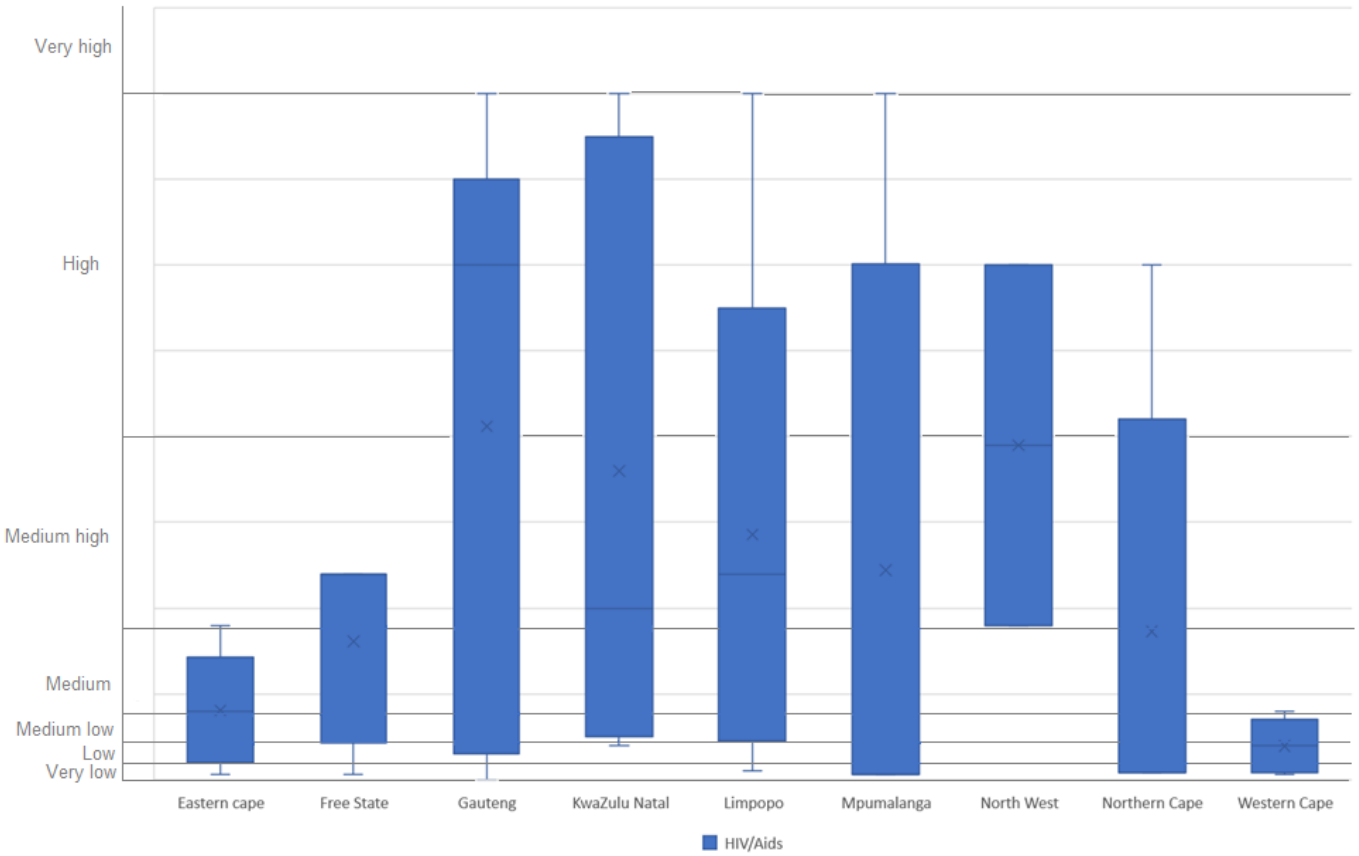
Table 22. Ranking of provinces by average relative risk rankings

Ranking	HIV/Aids
1	Gauteng
2	North West
3	KwaZulu Natal
4	Limpopo
5	Mpumalanga
6	Northern Cape
7	Free State
8	Eastern Cape
9	Western Cape

Table 23. Ranking of Districts by Relative Risk Ranking

Rank	HIV/Aids
1	Sedibeng District (Gauteng), eThekwini Metro District (KwaZulu Natal), Ilembe District (KwaZulu Natal), uMgungundlovu District (KwaZulu Natal), Mopani District (Limpopo), Nkangala District (Mpumalanga)
2	City of Johannesburg Metro District (Gauteng), City of Tshwane Metro District (Gauteng), King Cetshwayo District (KwaZulu Natal), Namakwa District (Northern Cape), Bojanala Platinum District (North West), Ngaka Modiri Molema District (North West)
3	Sekhukhune District (Limpopo)
4	Fezile Dabi District (Free State), Lejweleputswa District (Free State), Thabo Mofutsanyane District (Free State), Uthukela District (KwaZulu Natal), Waterberg District (Limpopo), Frances Baard District (Northern Cape)
5	Zululand District (KwaZulu Natal)

Figure 6. Box and Whisker Graph of the Major Infectious Diseases Category



The national relative risk values are distributed across the relative risk ranks with some clustering at the bottom, middle, and upper ranks. The national relative risk distribution is as follows: very low 25%, low 4%, medium low 21%, medium 12%, medium high 15%, and high 23%.

Gauteng has the highest relative risk values, with 60% of districts having a high relative risk rank, and 20% with a medium low. KwaZulu Natal, Limpopo, and Mpumalanga all have the same highest relative risk values, with KwaZulu Natal and Limpopo having a similar distribution of relative risk ranks, although Limpopo has a greater percentage of very low relative risk values. Mpumalanga comparatively has 33% high, but 67% very low, hence its rank 5th rank in the average table.

The Eastern Cape, Free State, and Western Cape have the lowest HIV/Aids relative risk values, with the Western Cape having 50% medium low, and 50% low relative risk ranking. The Eastern Cape has 25% very low, 12.5% low, 12.5% medium low, and 50% medium relative risk rankings. The Free State's values are slightly higher with 60% of the relative risk ranks at medium high, while the remained are medium low, or very low.

Communicable, Maternal, Perinatal, and Nutritional

Table 24. National relative risk values

	Lower respiratory tract Infection	Diarrhoeal diseases	Preterm birth complications	Septicaemia	Meningitis/encephalitis	Sepsis/other newborn infections	Other perinatal conditions	Malaria
National Minimum	0	2	0	1	0	1	0	1
National Q2	6	14	8	8	2	8	6	5
National median	12	24	15	14	6	13	13	9
National Q3	20	30	21	19	15	19	21	17
National Maximum	40	48	40	31	40	45	44	44

Table 25. Ranking of provinces by average relative risk rankings

	Lower respiratory tract Infection	Diarrhoeal diseases	Preterm birth complications	Septicaemia	Meningitis/encephalitis	Sepsis/other newborn infections	Other perinatal conditions	Malaria
1	Free State	Limpopo	North West	Free State	North West	Limpopo	Free State	North West
2	KwaZulu Natal	North West	Northern Cape	Limpopo	KwaZulu Natal	North West	North West	Limpopo
3	Gauteng	Free State	Free State	North West	Gauteng	Northern Cape	Gauteng	Mpumalanga

4	Mpumalanga	Northern Cape	Limpopo	Gauteng	Limpopo	Free State	KwaZulu Natal	Free State
5	North West	Gauteng	Gauteng	Northern Cape	Mpumalanga	Gauteng	Mpumalanga	Gauteng
6	Eastern Cape	Mpumalanga	KwaZulu Natal	Mpumalanga	Free State	KwaZulu Natal	Eastern Cape	Northern Cape
7	Northern Cape	KwaZulu Natal	Eastern Cape	KwaZulu Natal	Northern Cape	Mpumalanga	Northern Cape	KwaZulu Natal
8	Limpopo	Eastern Cape	Mpumalanga	Eastern Cape	Eastern Cape	Eastern Cape	Limpopo	Eastern Cape
9	Western Cape	Western Cape	Western Cape	Western Cape	Western Cape	Western Cape	Western Cape	Western Cape

Table 26. Ranking of district by average relative risk rankings

Rank	Lower respiratory tract Infection	Diarrhoeal diseases	Preterm birth complications	Septicaemia	Meningitis/ encephalitis	Sepsis/other newborn infections	Other perinatal conditions	Malaria
1	Fezile Dabi District (Free State), Sedibeng District (Gauteng), eThekwini Metro District (KwaZulu Natal)	Mopani District (Limpopo)	eThekwini Metro District (KwaZulu Natal)	Mopani District (Limpopo)	Ilembe District (KwaZulu Natal), King Cetshwayo District (KwaZulu Natal), Mopani District (Limpopo), Bojanala Platinum District (North West), Ngaka Modiri Molema District (North West)	Mopani District (Limpopo)	Thabo Mofutsanyane District (Free State)	Mopani District (Limpopo)

2	Ugu District (KwaZulu Natal)	Sedibeng District (Gauteng)	Mopani District (Limpopo)	City of Johannesburg Metro District (Gauteng)	City of Johannesburg Metro District (Gauteng), uMgungundlovu District (KwaZulu Natal)	Bojanala Platinum District (North West)	Ugu District (KwaZulu Natal)	Vhembe District (Limpopo)
3	Thabo Mofutsanyane District (Free State)	Fezile Dabi District (Free State)	Bojanala Platinum District (North West)	Fezile Dabi District (Free State), Thabo Mofutsanyane District (Free State), Sedibeng District (Gauteng)	City of Tshwane Metro District (Gauteng), Sedibeng District (Gauteng), eThekwini Metro District (KwaZulu Natal), Zululand District (KwaZulu Natal), Nkangala District (Mpumalanga), Namakwa District (Northern Cape)	Fezile Dabi District (Free State), Ngaka Modiri Molema District (North West)	Fezile Dabi District (Free State)	Bojanala Platinum District (North West), Ngaka Modiri Molema District (North West)
4	Alfred Nzo District (Eastern Cape), Nelson Mandela Bay Metro District (Eastern Cape), City of Johannesburg Metro District (Gauteng), uMgungundlovu District (KwaZulu Natal),	Sekhukhune District (Limpopo)	Sedibeng District (Gauteng)	Vhembe District (Limpopo)	City of Tshwane Metro District (Gauteng), Sedibeng District (Gauteng), eThekwini Metro District (KwaZulu Natal), Zululand District (KwaZulu Natal), Nkangala District (Mpumalanga), Namakwa District (Northern	Thabo Mofutsanyane District (Free State), City of Johannesburg Metro District (Gauteng)	uMzinyathi District (KwaZulu Natal)	Thabo Mofutsanyane District (Free State)

	uMzinyathi District (KwaZulu Natal), Uthukela District (KwaZulu Natal), Dr. Kenneth Kaunda District (North West)				Cape)			
5	ZF Mgcawu District (Northern Cape)	Thabo Mofutsanyane District (Free State), City of Johannesburg Metro District (Gauteng)	Namakwa District (Northern Cape)	Ugu District (KwaZulu Natal)	Ugu District (KwaZulu Natal), Dr. Kenneth Kaunda District (North West), Dr. Ruth Segomotsi Mompati District (North West)	Ugu District (KwaZulu Natal)	Nkangala District (Mpumalanga)	Dr. Ruth Segomotsi Mompati District (North West)

Table 27. Summarised Communicable, Maternal, Perinatal, and Nutritional Sub-Categories Ranking by Count of District Rankings

Rank:	Diseases (number of districts):
1st	Diarrhoeal diseases (27)
2nd	Lower Respiratory tract infections (10), preterm birth complications (9)
3rd	Septicaemia (12)
4th	Other perinatal conditions (10)
5th	Sepsis/other newborn infections (10)
6th	Mengigitis/encephalitis (5)

Table 28. Full Communicable, Maternal, Perinatal, and Nutritional Sub-Categories Ranking by Count of District Rankings

Province Top 6 Count:	1	2	3	4	5	6
Lower respiratory tract Infection	6	10	7	2	6	7
Diarrhoeal diseases	27	19	6	0	0	0
Preterm birth complications	2	9	10	7	9	7
Septicaemia	1	3	12	13	9	8
Meningitis/encephalitis	7	2	2	4	1	5
Sepsis/other newborn infections	0	4	7	8	10	13
Other perinatal conditions	5	4	8	10	9	9
Malaria	5	3	2	9	9	7

Figure 7. Box and Whisker Graph of the Communicable, Maternal, Perinatal, and Nutritional Category

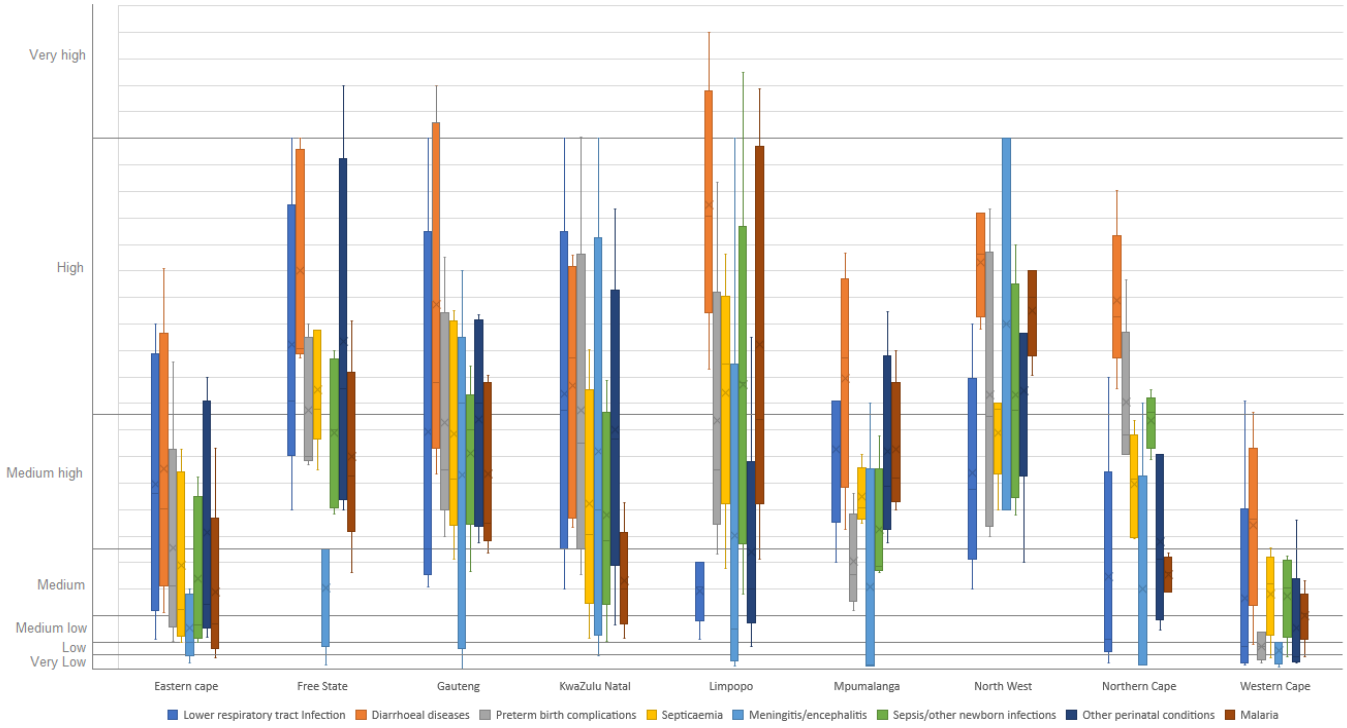


Table 29. Communicable, Maternal, Perinatal, and Nutritional Category

Disease	Convergent	Divergent
Lower respiratory tract Infection	Relative risk ranks are clustered between medium to high, with medium (27%), medium high (19%), and high (35%). Most significant relative risk values in KZN, and GP, although the GP values are split between medium, and high. Second highest relative risk in EC, GP, and WC.	LM is the most significant outlier with much lower relative risk rank compared to other sub-categories, when compared to the distribution of sub-categories in other provinces. NW, and NC are further outliers, where lower respiratory tract infections rank among lowest sub-categories at risk for the province – although relative risk in NW is still fairly high with medium (25%), medium high (50%), and high (25%)
Diarrhoeal diseases	Most significant relative risk nationally, and highest ranked by count in EC, FS GP, LIM, NC, and WC. National relative risk is medium high (25%), and high (63%). Ranked the most significant sub-category at risk in 27 districts, and 2nd most at risk in 19 others, making it in the top 2 for 46 of 52 districts.	
Preterm birth complications	Falls in 2nd rank in Table 27, however at a comparatively lower count. When looking at provincial data in Figure **7** it ranks at either 3rd or 4th relative risk rank for: EC, GP, KZN, LIM, and NW. Consistently medium to medium high relative risk, with national population at medium (17%), medium high (40%), and high (28%).	NC is an outlier with preterm birth complications ranking second highest. MP, and WC are further outliers with preterm birth complications ranking lowest.
Septicaemia	Calculated in Table 27 as having 3rd rank, however majority of districts septicaemia ranks between 3rd to 6th rank.	

<table>
<tr>
<td></td>
<td>At national level relative risk is clustered between medium to high, with medium (18%), medium high (53%), and high (17%). From Table 27. Summarised Communicable, Maternal, Perinatal, and Nutritional Sub-Categories Ranking by Count of District Rankings
<table>
<tr><th>Rank:</th><th>Diseases (number of districts):</th></tr>
<tr><td>1st</td><td>Diarrhoeal diseases (27)</td></tr>
<tr><td>2nd</td><td>Lower Respiratory tract infections (10</td></tr>
<tr><td>3rd</td><td>Septicaemia (12)</td></tr>
<tr><td>4th</td><td>Other perinatal conditions (10)</td></tr>
<tr><td>5th</td><td>Sepsis/other newborn infections (10)</td></tr>
<tr><td>6th</td><td>Mengigitis/encephalitis (5)</td></tr>
</table>
Table 28. Full Communicable, Maternal, Perinatal, and Nutritional Sub-Categories Ranking by Count of District Rankings
<table>
<tr><th>Province Top 6 Count:</th></tr>
<tr><td>Lower respiratory tract Infection</td></tr>
<tr><td>Diarrhoeal diseases</td></tr>
<tr><td>Preterm birth complications</td></tr>
<tr><td>Septicaemia</td></tr>
<tr><td>Meningitis/encephalitis</td></tr>
<tr><td>Sepsis/other newborn infections</td></tr>
<tr><td>Other perinatal conditions</td></tr>
<tr><td>Malaria</td></tr>
</table>
Figure 7 can see it ranks in the medium-tier for all provinces.</td>
<td></td>
</tr>
<tr>
<td>Meningitis/encephalitis</td>
<td>National population is clustered in two areas around medium high (20%), and medium (20%), with the majority at lower relative risk with very low (23%), and low, and medium low (12% both).
Table 27. Summarised Communicable, Maternal, Perinatal, and Nutritional Sub-Categories Ranking by Count of District Rankings
<table>
<tr><th>Rank:</th><th>Diseases (number of districts):</th></tr>
<tr><td>1st</td><td>Diarrhoeal diseases (27)</td></tr>
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<tr><td>5th</td><td>Sepsis/other newborn infections (</td></tr>
<tr><td>6th</td><td>Mengigitis/encephalitis (5)</td></tr>
</table>
</td>
<td>NW is an outlier with a meningitis/encephalitis ranking comparatively higher to other sub-categories, with 50% high, and 50% medium high.</td>
</tr>
</table>

	Table 28. Full Communicable, Maternal, Perinatal, and Nutritional Sub-Categories Ranking by Count of District Rankings **Province Top 6 Count:** Lower respiratory tract Infection Diarrhoeal diseases Preterm birth complications Septicaemia Meningitis/encephalitis Sepsis/other newborn infections Other perinatal conditions Malaria **Figure 7** demonstrates this distribution with a low mean for EC, FS, LIM, MP, NC, and WC, and a medium mean for GP, and KZN. GP, and KZN interestingly follow the national distribution closely, with KZN having a cluster around medium low to high, and GP with a cluster at very low (20%), and at medium low (20%), and medium high (40%), to high (20%).	
Sepsis/other newborn infections	Ranking in Table 27 is at 5th, with the next highest rankings in 6th, and 4th. National relative risk is clustered around medium high, with medium (22%), medium high (45%), and high (12%), indicating that sepsis/other newborn infections is of medium high risk nationally.	LIM has a higher percentage of very high (20%), and high (40%) relative risk values, indicating a higher risk to Sepsis/other newborn infections than the rest of the country. Similarly NW has elevated risk medium high (50%), and high (50%), while the WC has the lowest overall risk with medium (67%), medium low (17%), and very low (17%)
Other perinatal conditions	Other perinatal conditions are ranked 4th on Table 27, with the next highest count of rankings at 3rd, 5th, and 6th. National relative risk levels are clustered around medium risk, with medium low (25%), medium (38%), medium high (13%), and high (25%). Most provinces follow the national relative risk population, although GP, and KZN have a higher proportion of medium high to high.	FS has an overall higher relative risk level with medium high (40%), high (40%), and very high (20%), and the highest relative risk value for the sub-category. Similarly, NW has a much higher proportion of high (75%), and has the second highest average relative risk value. By contrast the WC has the lowest average relative risk values, with very low (67%), medium low (17%), and medium high (17%).
Malaria	Table 27. **Summarised Communicable, Maternal, Perinatal, and Nutritional Sub-Categories Ranking by Count of District Rankings**	LM, MP, and NW are outliers where malaria ranks highly for relative risk. Note NW relative risk rank is descriptive of climate conditions for malaria, rather than anticipated distribution range.

Rank:	Diseases (number of districts
1st	Diarrhoeal diseases (27)
2nd	Lower Respiratory tract infections
3rd	Septicaemia (12)
4th	Other perinatal conditions (10)
5th	Sepsis/other newborn infections (
6th	Mengigitis/encephalitis (5)

Table 28. Full Communicable, Maternal, Perinatal, and Nutritional Sub-Categories Ranking by Count of District Rankings

Province Top 6 Count:
Lower respiratory tract Infection
Diarrhoeal diseases
Preterm birth complications
Septicaemia
Meningitis/encephalitis
Sepsis/other newborn infections
Other perinatal conditions
Malaria

Figure 7 demonstrates malaria is of comparatively lower concern for all provinces, although this is a reflection of their climatic conditions for malaria, rather than anticipated risk given future distribution range.

Non-Communicable Diseases

Note that endocrine, nutritional, blood, and immune system; diabetes mellites; and prostate all have no interaction with climate change exposures on the interaction table in the Tool, and as such there are no relative risk values for them.

Table 30. National relative risk values

	Cardiovascular disease	Hypertensive heart disease	Ischaemic heart disease	Chronic obstructive pulmonary disease	Nephritis/ nephrosis	Epilepsy	Asthma

National Minimum	1	1	0	1	0	0	1
National Q2	12	5	4	6	2	3	10
National median	19	19	17	14	6	8	15
National Q3	33	44	44	19	20	20	20
National Maximum	71.66666667	100	80	38.33333333	40	40	31.25

Table 31. Ranking of provinces by average relative risk rankings

Rank	Cardiovascular disease	Hypertensive heart disease	Ischaemic heart disease	Chronic obstructive pulmonary disease	Nephritis/ nephrosis	Epilepsy	Asthma
1	Limpopo	Limpopo	Limpopo	Limpopo	Limpopo	Free State	Limpopo
2	Northern Cape	Northern Cape	Northern Cape	North West	North West	Gauteng	Free State
3	North West	North West	North West	Western Cape	Northern Cape	North West	Gauteng
4	Gauteng	Gauteng	Western Cape	Gauteng	Gauteng	KwaZulu Natal	KwaZulu Natal
5	Western Cape	Free State	Gauteng	Mpumalanga	KwaZulu Natal	Eastern Cape	North West
6	Mpumalanga	Mpumalanga	Mpumalanga	Northern Cape	Mpumalanga	Limpopo	Northern Cape
7	Free State	Western Cape	Free State	Free State	Free State	Mpumalanga	Mpumalanga
8	KwaZulu Natal	KwaZulu Natal	KwaZulu Natal	KwaZulu Natal	Eastern Cape	Northern Cape	Eastern Cape
9	Eastern Cape	Eastern Cape	Eastern Cape	Eastern Cape	Western Cape	Western Cape	Western Cape

Table 32 Ranking of Districts by Relative Risk Ranking

Rank	Cardiovascular disease	Hypertensive heart disease	Ischaemic heart disease	Chronic obstructive pulmonary disease	Nephritis/nephrosis	Epilepsy	Asthma
1	Mopani District (Limpopo), Vhembe District (Limpopo)	Capricorn District (Limpopo), Sekhukhune District (Limpopo)	Capricorn District (Limpopo), Mopani District (Limpopo), Vhembe District (Limpopo), Sekhukhune District (Limpopo), John Taolo Gaetsewe District (Northern Cape)	Mopani District (Limpopo)	Mopani District (Limpopo), Bojanala Platinum District (North West)	Sedibeng District (Gauteng)	Mopani District (Limpopo)
2	Sekhukhune District (Limpopo)	Mopani District (Limpopo), Vhembe District (Limpopo), John Taolo Gaetsewe District (Northern Cape)	West Rand District (Gauteng), Frances Baard District (Northern Cape), Pixley Ka Seme District (Northern Cape), Cape Winelands District (Western Cape), Central Karoo District (Western Cape)	Capricorn District (Limpopo)	Ngaka Modiri Molema District (North West)	Alfred Nzo District (Eastern Cape), Fezile Dabi District (Free State), City of Johannesburg Metro District (Gauteng), King Cetshwayo District (KwaZulu Natal), Ugu District (KwaZulu Natal), Zululand District (KwaZulu Natal), Bojanala Platinum District (North West), Ngaka Modiri Molema District (North West)	eThekwini Metro District (KwaZulu Natal)
3	Capricorn District (Limpopo)	Waterberg District (Limpopo), Pixley Ka Seme	King Cetshwayo District (KwaZulu Natal), Namakwa District	Sekhukhune District (Limpopo)	Ilembe District (KwaZulu Natal), King Cetshwayo District (KwaZulu	Mangaung Metro District (Free State),	City of Johannesburg Metro District (Gauteng)

		District (Northern Cape)	(Northern Cape), Bojanala Platinum District (North West), Dr. Ruth Segomotsi Mompati District (North West), Ngaka Modiri Molema District (North West), Garden Route District (Western Cape)		Natal), Vhembe District (Limpopo)	Mopani District (Limpopo)	
4	Pixley Ka Seme District (Northern Cape)	King Cetshwayo District (KwaZulu Natal)	Waterberg District (Limpopo), ZF Mgcawu District (Northern Cape)	City of Johannesburg Metro District (Gauteng)	City of Tshwane Metro District (Gauteng), Sekhukhune District (Limpopo), Nkangala District (Mpumalanga)	Xhariep District (Free State)	Fezile Dabi District (Free State), Thabo Mofutsanyane District (Free State), Sedibeng District (Gauteng)
5	City of Johannesburg Metro District (Gauteng)	West Rand District (Gauteng), Frances Baard District (Northern Cape)	City of Johannesburg Metro District (Gauteng)	Cape Winelands District (Western Cape)	City of Johannesburg Metro District (Gauteng)	eThekwini Metro District (KwaZulu Natal)	King Cetshwayo District (KwaZulu Natal)

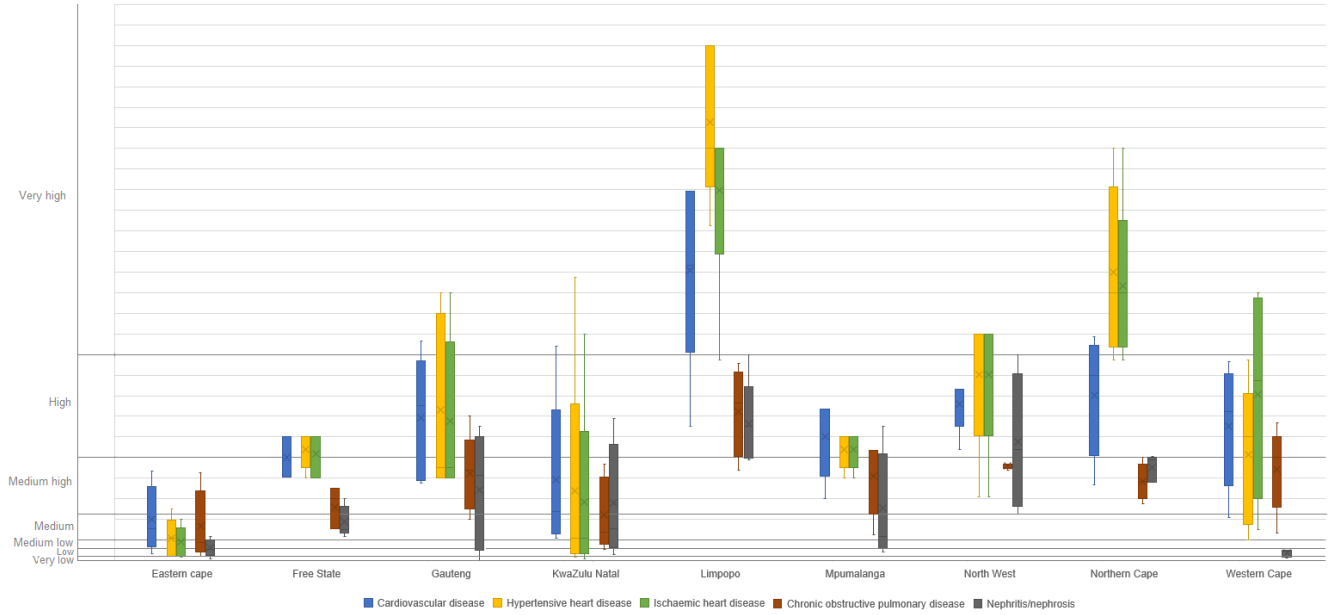
Table 33 Summarised Non-Communicable Diseases Sub-Categories Ranking by Count of District Rankings

Rank:	Diseases (number of districts):
1st	Hypertensive heart disease (25), ischaemic heart disease (20)
2nd	Cardiovascular disease (11)
3rd	Asthma (8), cardiovascular disease (23)
4th	Chronic obstructive pulmonary disease (15), nephritis/nephrosis (10)
5th	Epilepsy (6)

Table 34 Full Non-Communicable Diseases Sub-Categories Ranking by Count of District Rankings

Sub-category:	1st	2nd	3rd	4th	5th	6th	7th
Cardiovascular disease	7	11	23	6	4	1	0
Diabetes mellitus	0	0	0	0	0	0	1
Hypertensive heart disease	25	3	5	5	6	6	2
Ischaemic heart disease	20	8	5	4	6	6	3
Endocrine, nutritional, blood, immune system	0	0	0	0	0	0	1
Chronic obstructive pulmonary disease	1	3	3	15	17	5	8
Nephritis/nephrosis	2	3	3	10	8	13	13
Epilepsy	6	4	4	6	6	8	18
Asthma	8	6	8	7	9	12	2
Prostate	0	0	0	0	0	0	1

Figure 8. Box and Whisker Graph of the Non-Communicable Diseases Category



Rank	Value Range
Very Low	0=<X=<1
Low	1<X=<2
Medium Low	2<X=<4
Medium	4<X=<9
Medium High	9<X=<20
High	20<X=<40
Very High	40<X

Disease	Convergent	Divergent
Cardiovascular disease	Cardiovascular disease is among the top three sub-categories with the highest relative risk. Table 34 demonstrates that it is between the 1st to 3rd most at risk sub-category for 41 districts. The national population is clustered around high relative risk, with medium high (31%), high (33%), and very high (15%).	EC has the lowest relative risk levels, with a median value lower than all other provinces minimum value (except KZN). KZN's values are clustered around medium (45%), and medium high (45%), however King Cetshwayo district is a significant outlier with a very high relative risk rank. LIM has the highest relative risk values, its median value exceeding all other provinces maximum value, with high (20%), and very high (80%).
Hypertensive heart disease	Hypertensive heart disease is among the top three sub-categories with the highest relative risk, and as shown by Error! Not a valid result for table. and Table 34 is the sub-	LIM has the highest relative risk values, its median value exceeding all other provinces maximum value (except NW), with 100% of

	category which is most at risk in 25 districts. This sub-category has the second highest percentage of very high (29%) relative risk ranks, with high (19%), medium high (17%), and medium (19%).	relative risk ranks being very high. KZN's values are clustered around medium (45%), and very low (27%), however King Cetshwayo district is a significant outlier with a very high relative risk rank. EC has the lowest relative risk levels, with a median value lower than all other provinces minimum value (except KZN), and is an outlier in terms of it's relative risk compared to other sub-categories in the province.
Ischaemic heart disease	Ischaemic heart disease is among the top three sub-categories with the highest relative risk, and as shown by Error! Not a valid result for table. and Table 34 is the sub-category which is most at risk in 20 districts. Ischaemic heart disease has the largest number of very high (31%) relative risk ranked districts, with the remaining values clustered between medium (19%), medium high (17%), and high (17%).	The EC is again the outlier with the majority of relative risk values falling under medium (50%), medium low (12.5%) very low (37.5%). LIM has the highest relative risk ranks, with high (20%), and very high (80%). KZN's values are clustered around medium (45%), and very low (27%), however King Cetshwayo district is a significant outlier with a very high relative risk rank.
Chronic obstructive pulmonary disease	Error! Not a valid result for table. and Table 34 demonstrate chronic obstructive pulmonary disease ranks mainly between the 4th most significant relative risk category, to 5th. Chronic obstructive pulmonary disease national relative risk values are clustered around medium high (46%), with medium (23%), and high (19%). The EC, and KZN have some of the lowest relative risk values, although most provinces relative risk values fall with in a similar band.	LIM has the highest relative risk values, with its median values exceeding all other provinces max values.
Nephritis/nephrosis	Error! Not a valid result for table. and Table 34 demonstrate nephritis/nephrosis falls between the 4th to 7th sub-category at relative risk. Nephritis/nephrosis is evenly distributed across the relative risk ranks, although there are no very high relative risk ranks.	LIM has the highest relative risk ranks, with medium high (20%), and high (80%), followed by the NW which has medium (25%), medium high (25%), and high (50%). The EC, and WC are outliers with the lowest relative risk ranks. While GP, and MP have outlier districts with similarly low relative risk ranks, they are more evenly distributed among higher relative risk ranks.
Epilepsy	Epilepsy is evenly distributed across the relative risk ranks, although there are no very high relative risk ranks. It is also fairly evenly distributed across the sub-category relative risk rankings in Table 34. In the EC, FS, GP, and KZN epilepsy is among the sub-categories at more significant risk compared other sub-categories, while LM, MP, NW, NC, and WC	EC, and KZN are outliers in that epilepsy is has higher relative risk ranks in comparison to other sub-categories in the province, when compared to other provinces distributions. WC is the outlier with the lowest relative risk ranks, with very low (83%), and low (17%). LIM, and NW are outliers, as epilepsy ranks

	epilepsy is at far less significant risk compared to other sub-categories.	far lower in the relative risk ranks than band of relative risk ranks occupied by the other sub-categories.
Asthma	Asthma is clustered around medium high (52%), with medium (17%), and high (25%). In the EC, FS, GP, and KZN asthma is among the sub-categories at more significant risk compared other sub-categories, while LM, MP, NW, NC, and WC asthma is at far less significant risk compared to other sub-categories.	

Services

Ambulatory

Table 35 National relative risk values

	Acute curative - minor ailments incl diarrhoea, malaria, minor trauma etc	Preventive, promotive	Chronic care - communicable disease; mental; non-communicable
National Minimum	2	2	1
National Q2	8	11	13
National median	14	17	21
National Q3	18	28	35
National Maximum	26	54	67

Table 36 Ranking of provinces by average relative risk rankings

Rank	Acute curative - minor ailments including diarrhoea, malaria, minor trauma etc	Preventive, promotive	Chronic care - communicable disease; mental; non-communicable
1	Free State	KwaZulu Natal	Free State
2	North West	Free State	North West
3	Northern Cape	Mpumalanga	KwaZulu Natal
4	KwaZulu Natal	Eastern Cape	Gauteng

5	Limpopo	Northern Cape	Eastern Cape
6	Mpumalanga	Gauteng	Mpumalanga
7	Gauteng	Limpopo	Northern Cape
8	Eastern Cape	North West	Limpopo
9	Western Cape	Western Cape	Western Cape

Table 37 Ranking of Districts by Relative Risk Ranking

Rank	Acute curative - minor ailments including diarrhoea, malaria, minor trauma etc	Preventive, promotive	Chronic care - communicable disease; mental; non-communicable
1	Fezile Dabi District (Free State), Bojanala Platinum District (North West)	OR Tambo District (Eastern Cape)	OR Tambo District (Eastern Cape)
2	Thabo Mofutsanyane District (Free State), Ilembe District (KwaZulu Natal), Mopani District (Limpopo)	eThekwini Metro District (KwaZulu Natal)	Fezile Dabi District (Free State)
3	uMgungundlovu District (KwaZulu Natal), Nkangala District (Mpumalanga)	ZF Mgcawu District (Northern Cape)	Thabo Mofutsanyane District (Free State), Sedibeng District (Gauteng)
4	eThekwini Metro District (KwaZulu Natal)	Ilembe District (KwaZulu Natal)	eThekwini Metro District (KwaZulu Natal)
5	Namakwa District (Northern Cape), ZF Mgcawu District (Northern Cape)	uMgungundlovu District (KwaZulu Natal)	Nelson Mandela Bay Metro District (Eastern Cape)

Table 38 Summarised Ambulatory Sub-Categories Ranking by Count of District Rankings

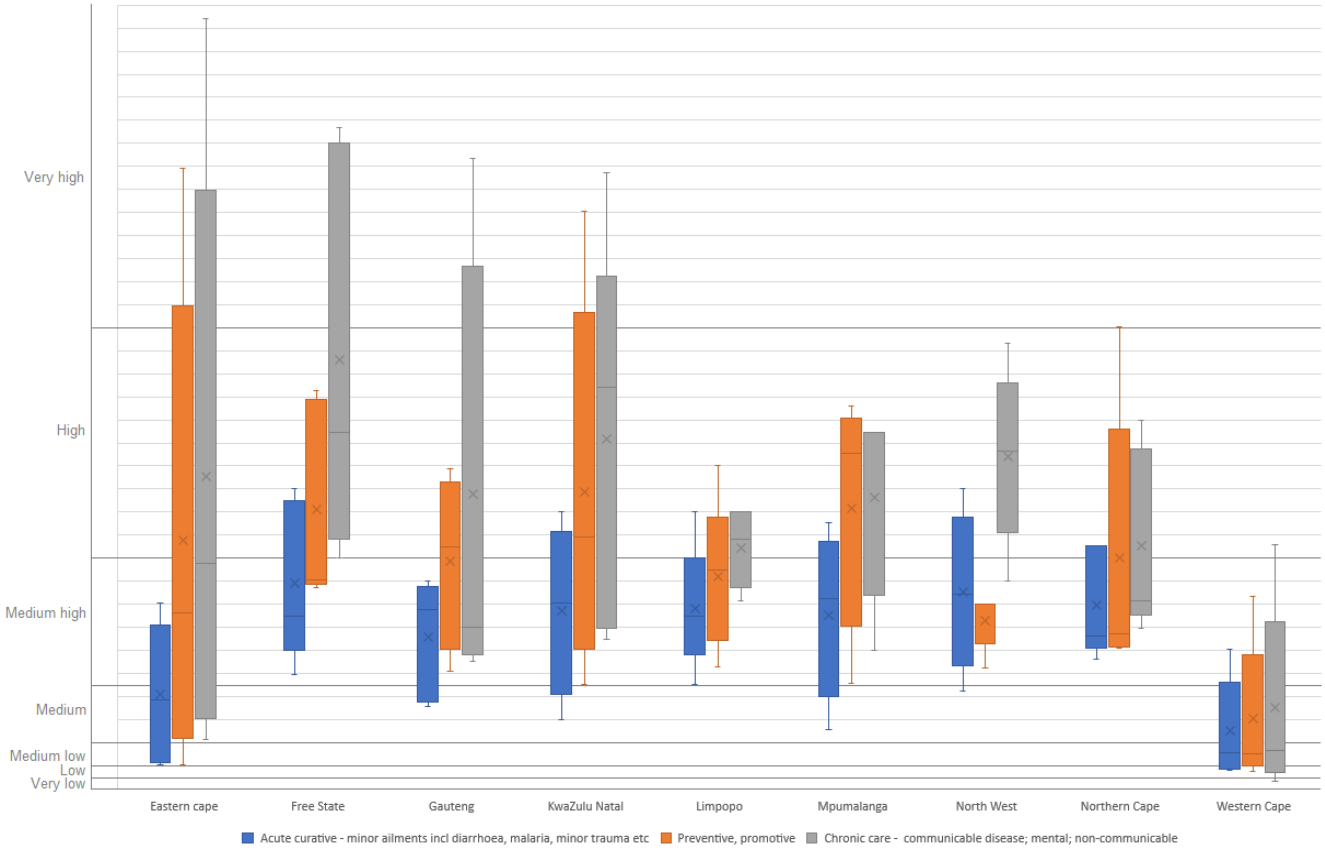
Rank:	Services (number of districts):
1st	Chronic care - communicable disease; mental; non-communicable (36)
2nd	Preventive, promotive (32)
3rd	Acute curative - minor ailments including diarrhoea, malaria, minor trauma etc (40)

Table 39 Full Ambulatory Sub-Categories Ranking by Count of District Rankings

Rank	Acute curative - minor ailments including diarrhoea, malaria, minor trauma etc	Preventive, promotive	Chronic care - communicable disease; mental; non-communicable
1	2	14	36
2	10	32	10

3	40	6	5

Figure 9 Box and Whisker Graph of the Ambulatory Category



Disease	Convergent	Divergent
Acute curative - minor ailments including diarrhoea, malaria, minor trauma etc	This sub-category is at the lowest risk in this category for all provinces except NW. Relative risk values are clustered around medium high, with medium (17%), medium high (50%), and high (19%).	In NW this sub-category is the second most highest at risk category of services, although relative risk is split between medium (25%), medium high (50%), and high (25%). The WC has the lowest relative risk values in SA, with relative risk ranks clustered at low (33%), medium low (17%), and medium (33%).
Preventive, promotive	Second most at relative risk sub-category nationally. Relative risk ranks are clustered around medium (10%), medium high (42%), and high (33%).	NW is an outlier with preventive, and promotive ranking as the second most at relative risk sub-category. The WC has the lowest relative risk values in SA, with relative risk ranks clustered at low (17%), medium low (50%), and medium (17%), and medium high (17%). The EC has the widest distribution of relative risk values, with only the EC, KZN, and NC

		having districts which are at very high relative risk.
Chronic care - communicable disease; mental; non-communicable	This is the sub-category at the most relative risk in SA, however it is important to note that there is a wide distribution to most provinces relative risk ranks. The relative risk ranks are clustered around medium high (35%), high (40%), and very high (12%).	The WC has the widest distribution of values, with very low (17%), low (17%), medium low (33%), medium high (17%), and high (17%).

Community

Table 40 National relative risk values

	Environmental health services	Community services & health promotion	Malaria or other specific programs
National Minimum	2	2	0
National Q2	12	13	7
National median	20	19	13
National Q3	32	32	30
National Maximum	64	54	100

Table 41 Ranking of provinces by average relative risk rankings

Rank	Environmental health services	Community services & health promotion	Malaria or other specific programs
1	North West	North West	Free State
2	Gauteng	Free State	Mpumalanga
3	Free State	Mpumalanga	Gauteng
4	KwaZulu Natal	Gauteng	North West
5	Mpumalanga	KwaZulu Natal	Eastern Cape
6	Eastern Cape	Eastern Cape	KwaZulu Natal
7	Limpopo	Limpopo	Northern Cape
8	Northern Cape	Northern Cape	Limpopo

9	Western Cape	Western Cape	Western Cape

Table 42 Ranking of Districts by Relative Risk Ranking

Rank	Environmental health services	Community services & health promotion	Malaria or other specific programs
1	Sedibeng District (Gauteng)	OR Tambo District (Eastern Cape)	OR Tambo District (Eastern Cape)
2	OR Tambo District (Eastern Cape)	eThekwini Metro District (KwaZulu Natal)	Fezile Dabi District (Free State), Thabo Mofutsanyane District (Free State), Sedibeng District (Gauteng)
3	eThekwini Metro District (KwaZulu Natal)	Fezile Dabi District (Free State)	City of Johannesburg Metro District (Gauteng), uMgungundlovu District (KwaZulu Natal), Dr. Kenneth Kaunda District (North West)
4	Fezile Dabi District (Free State)	uMgungundlovu District (KwaZulu Natal)	Ehlanzeni District (Mpumalanga)
5	uMgungundlovu District (KwaZulu Natal)	Thabo Mofutsanyane District (Free State)	Buffalo City Metro District (Eastern Cape), ZF Mgcawu District (Northern Cape)

Table 43 Summarised Community Sub-Categories Ranking by Count of District Rankings

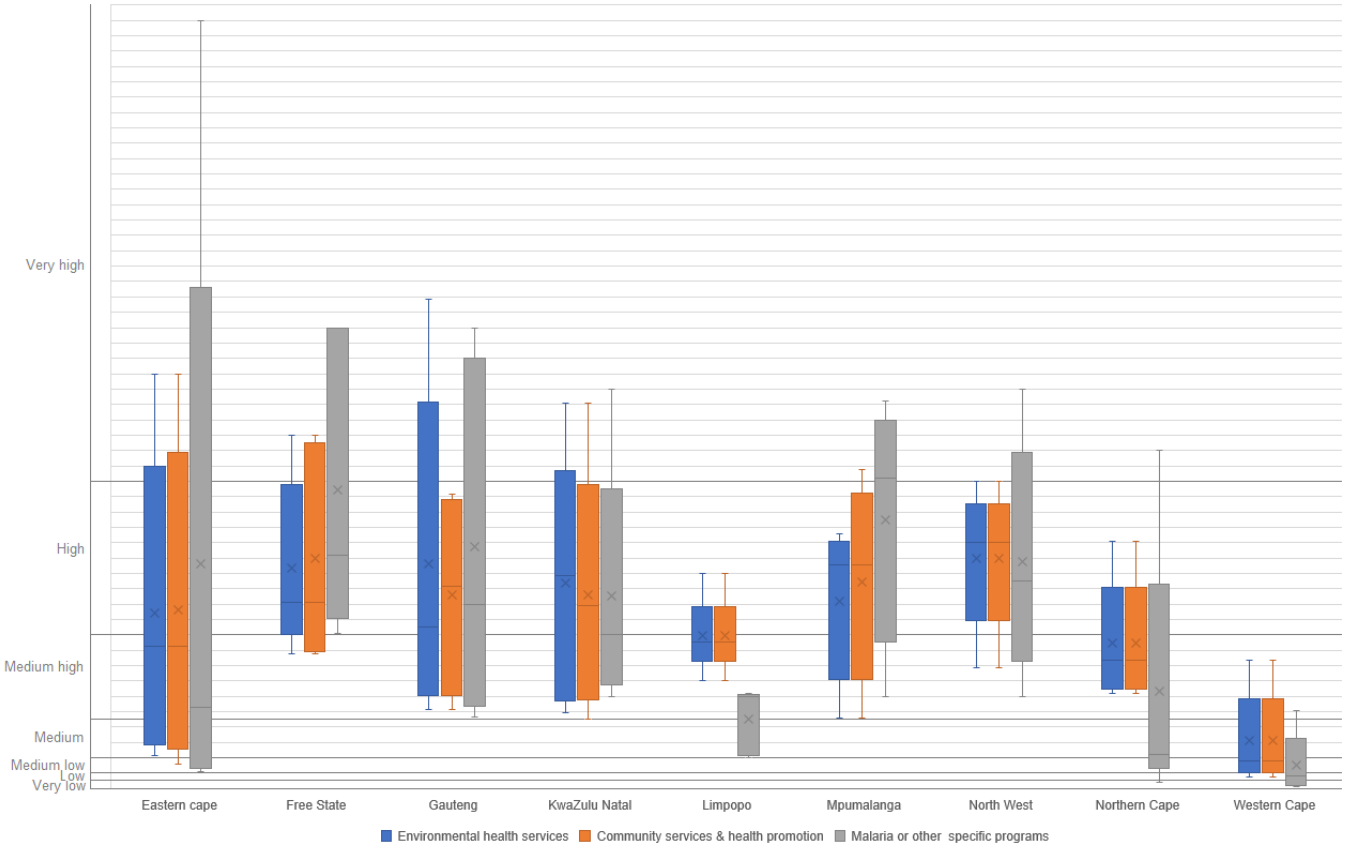
Rank:	Services (number of districts):
1st	Environmental health services (30), community services & health promotion (30)
2nd	Malaria and other specific programs (30)

Note that more than one service can be in the a given rank for a district if they have the same relative risk values, hence why we see values for 60 districts for 1st rank.

Table 44 Full Community Sub-Categories Ranking by Count of District Rankings

Rank	Environmental health services	Community services & health promotion	Malaria or other specific programs
1	30	30	18
2	18	19	30
3	4	3	4

Figure 10 Box and Whisker Graph of the Community Category



Disease	Convergent	Divergent
Environmental health services	This sub-category, alongside community services and health promotion, are the sub-categories at the highest risk in the most districts. Environmental health services have a slightly higher percentage of high relative risk ranks, with medium high (33%), high (40%), very high (10%).	
Community services and health promotion	This sub-category, alongside environmental health services, are the sub-categories at the highest risk in the most districts. Community services and health promotion have a slightly higher percentage of very high relative risk ranks, with medium high (35%), high (35%), very high (12%).	
Malaria and other specific programs	This sub-category ranks has the largest number of relative risk values which are 2nd most at risk in the districts, although there are 18 districts where it is the sub-category at the most risk. This sub-category has the largest distribution of relative risk ranks ranging from very low (6%), low (2%), medium low	LIM, and WC are outliers as they are the only provinces which do not have any districts with very high relative risk ranks. The EC by contrast has the widest distribution of relative risk ranks from medium low to very high.

	(12%), medium (8%), medium high (31%), high (21%), and very high (21%).	

Hospital casualty, inpatient, specialist ambulatory services

Table 45 National relative risk values

	Casualty	Obstetrics and Gynae	Surgery & orthopaedic – acute; elective	Medical	Paediatric	OPD	Ambulance, referrals, transport
National Minimum	1	0	0	1	1	1	1
National Q2	10	2	6	9	9	6	11
National median	20	24	18	16	23	14	19
National Q3	28	60	41	29	36	20	32
National Maximum	41	100	60	41	72	31	52

Table 46 Ranking of provinces by average relative risk rankings

Rank	Casualty	Obstetrics and Gynae	Surgery & orthopaedic – acute; elective	Medical	Paediatric	OPD	Ambulance, referrals, transport
1	North West	Mpumalanga	Mpumalanga	North West	Free State	North West	North West
2	Mpumalanga	KwaZulu Natal	KwaZulu Natal	Mpumalanga	KwaZulu Natal	Limpopo	Mpumalanga
3	Limpopo	Eastern Cape	Free State	Limpopo	Gauteng	Northern Cape	Free State
4	Gauteng	North West	Gauteng	Free State	North West	Gauteng	Northern Cape
5	Northern Cape	Free State	Eastern Cape	KwaZulu Natal	Mpumalanga	KwaZulu Natal	Limpopo
6	KwaZulu Natal	Gauteng	North West	Gauteng	Eastern Cape	Mpumalanga	Gauteng
7	Free State	Limpopo	Limpopo	Northern Cape	Limpopo	Free State	KwaZulu Natal
8	Eastern Cape	Western Cape	Western Cape	Eastern Cape	Northern Cape	Eastern Cape	Eastern Cape

9	Western Cape	Northern Cape	Northern Cape	Western Cape	Western Cape	Western Cape	Western Cape

Table 47 Ranking of Districts by Relative Risk Ranking

Rank	Casualty	Obstetrics and Gynae	Surgery & orthopaedic – acute; elective	Medical	Paediatric	OPD	Ambulance, referrals, transport
1	OR Tambo District (Eastern Cape), Nkangala District (Mpumalanga)	OR Tambo District (Eastern Cape)	OR Tambo District (Eastern Cape)	OR Tambo District (Eastern Cape)	OR Tambo District (Eastern Cape)	Sedibeng District (Gauteng)	Sedibeng District (Gauteng), ZF Mgcawu District (Northern Cape)
2	eThekwini Metro District (KwaZulu Natal)	Buffalo City Metro District (Eastern Cape), Nelson Mandela Bay Metro District (Eastern Cape), Fezile Dabi District (Free State), City of Johannesburg Metro District (Gauteng), eThekwini Metro District (KwaZulu Natal), uMgungundlovu District (KwaZulu Natal), Uthukela District (KwaZulu Natal), Ehlanzeni District (Mpumalanga), Nkangala District (Mpumalanga), Dr. Kenneth Kaunda District (North West)	Nkangala District (Mpumalanga)	eThekwini Metro District (KwaZulu Natal)	eThekwini Metro District (KwaZulu Natal)	eThekwini Metro District (KwaZulu Natal)	OR Tambo District (Eastern Cape)
3	City of Johannesburg Metro District (Gauteng)	Thabo Mofutsanyane District (Free State), Sedibeng District (Gauteng), Ilembe District	Nelson Mandela Bay Metro District (Eastern Cape), City of Johannesburg Metro District (Gauteng),	Fezile Dabi District (Free State)	Fezile Dabi District (Free State), Thabo Mofutsanyane District (Free State)	Mopani District (Limpopo)	Fezile Dabi District (Free State)

		(KwaZulu Natal), City of Cape Town Metro District (Western Cape)	Ilembe District (KwaZulu Natal), uMgungundlovu District (KwaZulu Natal), Uthukela District (KwaZulu Natal), Dr. Kenneth Kaunda District (North West)				
4	Mopani District (Limpopo)	ZF Mgcawu District (Northern Cape)	Fezile Dabi District (Free State), Thabo Mofutsanyane District (Free State), Sedibeng District (Gauteng), eThekwini Metro District (KwaZulu Natal)	Thabo Mofutsanyane District (Free State), City of Johannesburg Metro District (Gauteng), Ilembe District (KwaZulu Natal)	Sedibeng District (Gauteng)	OR Tambo District (Eastern Cape)	Dr. Kenneth Kaunda District (North West)
5	uMgungundlovu District (KwaZulu Natal)	Alfred Nzo District (Eastern Cape), Lejweleputswa District (Free State)	Buffalo City Metro District (Eastern Cape)	Mopani District (Limpopo)	City of Johannesburg Metro District (Gauteng), Ilembe District (KwaZulu Natal), uMgungundlovu District (KwaZulu Natal)	Namakwa District (Northern Cape), ZF Mgcawu District (Northern Cape)	Thabo Mofutsanyane District (Free State)

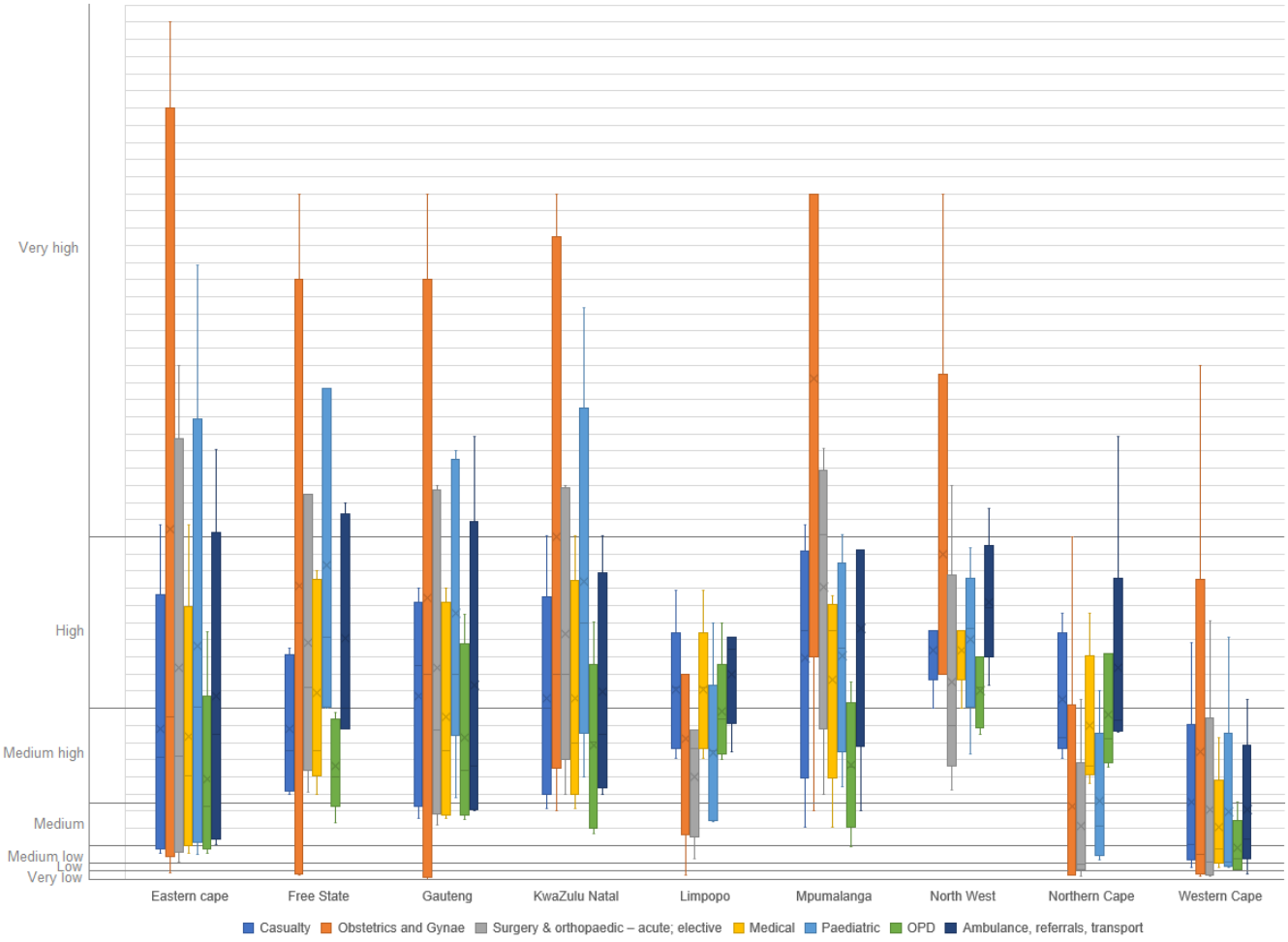
Table 48 Summarised Hospital Casualty, Inpatient, Specialist Ambulatory Services Sub-Categories Ranking by Count of District Rankings

Rank:	Services (number of districts):
1st	Obstetrics and gynae (22)
2nd	Surgery and orthopaedic – acute; elective (13), paediatric (12)
3rd	Casualty (13), medical (12)
4th	Ambulance, referrals, transport (14), OPD (9)

Table 49 Full Hospital Casualty, Inpatient, Specialist Ambulatory Services Sub-Categories Ranking by Count of District Rankings

Rank	Casualty	Obstetrics and Gynae	Surgery & orthopaedic – acute; elective	Medical	Paediatric	OPD	Ambulance, referrals, transport
1st	3	22	0	1	13	0	14
2nd	9	9	13	5	12	1	9
3rd	13	2	12	12	8	7	8
4th	11	2	7	13	5	9	14
5th	12	6	6	15	9	6	5
6th	4	1	4	4	3	2	1

Figure 11 Whisker Graph of the Hospital Casualty, Inpatient, Specialist Ambulatory Services Category



Disease	Convergent	Divergent
Casualty	Table 49 demonstrates how casualty has the most relative risk categories at the 3rd highest relative risk in the districts, with a large number at 4th, and 5th rank. The relative risk ranks are clustered between medium (15%), medium high (31%), and high (40%).	LIM, and NC are outliers, where casualty is at a high relative risk level compared to other sub-categories, when compared to other provinces distributions.
Obstetrics and gynae	Table 49 demonstrates how casualty has the most relative risk categories at the 1st highest relative risk in districts, with the remaining values being fairly evenly distributed between the ranks. Obstetrics and gynae has one of the widest distributions in this category, with relative risk ranks of very low (25%), to high (27%),	Almost all the provinces follow the national distribution, except KZN, and MP which have no very low to medium low values, and the NW where values are all in high (75%), or very high (25%) relative risk ranks.

	very high (29%).	
Surgery and orthopaedic – acute; elective	Table 49 demonstrates how surgery and orthopaedic – acute; elective has the most relative risk categories at the 2nd and 3rd highest relative risk in districts. Surgery and orthopaedic – acute; elective are clustered between medium (12%), medium high (31%), high (12%), and very high (27%). A fairly standard distribution rang is seen across the country.	LIM, and NC are outliers, with relative risk ranks falling at the lower end of the national distribution, and comparatively lower than other sub-categories in their provinces, when compared to other provinces. Surgery and orthopaedic – acute; elective ranks in the 5th , and 6th most at relative risk in these provinces, far below the national distribution.
Medical	Medical is distributed between the 3rd, 4th, and 5th relative risk rankings on Table 49, making it comparatively between moderate to low concern in most provinces. It's relative risk ranks are clustered between medium (17%), medium high (33%), and high (37%), which indicates a higher level of concern indicated by Table 49, however this does indicate a high level of risk across this category of services.	LIM is an outlier as medical is of a higher concern relative to other sub-categories (falling in 1st, 2nd, and 3rd), when compared to other provinces. Similarly, NC sees a highest relative risk to medical, with the sub-category mainly falling into the 3rd most at relative risk category.
Paediatric	Paediatric has a wider distribution of rankings on Table 49, however the majority are at 1st and 2nd most at relative risk sub-category in the districts. Paediatric relative risk ranks are clustered between medium (12%), medium high (21%), high (37%), and very high (17%).	This distribution holds for most provinces, except for NC where it ranks significantly lower in the 6th rank.
OPD	Table 49 demonstrates how OPD is mainly distributed between the 3rd, 4th, and 5th most at relative risk sub-categories in the districts. The relative risk ranks are clustered medium (19%), medium high (42%), and high (25%).	The EC, KZN, MP, and WC have OPD relative risk ranks which come in between 5th to 7th in terms of most at risk, which is significantly lower than that of provinces.
Ambulance, referrals, and transport	Ambulance, referrals, and transport has a wider distribution on Table 49, mainly falling on 1st and 4th , with the remaining values distributed between these two ranks. The relative risk ranks are clustered between medium (19%), medium high (31%), high (35%), and very high (13%).	The WC is an outlier in that it is the only province with a district with a very low relative risk rank.

Support Services

Table 50. National relative risk values

	Clinical e.g. Laboratory, Radiology, Pharmacy	Allied medical	IT, HIS and Tele-medicine	Non-clinical - support services	Infection control, occupational health & safety
National Minimum	0	0	0	2	1
National Q2	8	3	5	9	12
National median	16	12	12	13	23
National Q3	19	26	25	20	51
National Maximum	34	40	50	27	65

Table 51. Ranking of provinces by average relative risk rankings

Rank	Clinical e.g. Laboratory, Radiology, Pharmacy	Allied medical	IT, HIS and Tele-medicine	Non-clinical - support services	Infection control, occupational health & safety
1	Free State	Gauteng	Free State	Limpopo	Limpopo
2	North West	North West	Gauteng	Gauteng	North West
3	Limpopo	KwaZulu Natal	Mpumalanga	North West	Free State
4	Gauteng	Mpumalanga	KwaZulu Natal	Northern Cape	Northern Cape
5	Northern Cape	Free State	Eastern Cape	Mpumalanga	Gauteng
6	Mpumalanga	Eastern Cape	North West	Free State	KwaZulu Natal
7	Eastern Cape	Limpopo	Limpopo	KwaZulu Natal	Eastern Cape
8	KwaZulu Natal	Northern Cape	Northern Cape	Eastern Cape	Mpumalanga
9	Western Cape	Western Cape	Western Cape	Western Cape	Western Cape

Table 52. Ranking of Districts by Relative Risk Ranking

Rank	Clinical e.g. Laboratory, Radiology, Pharmacy	Allied medical	IT, HIS and Tele-medicine	Non-clinical - support services	Infection control, occupational health & safety
1	OR Tambo District (Eastern Cape)	City of Ekurhuleni Metro District (Gauteng), City of Johannesburg Metro District (Gauteng), eThekwini Metro District (KwaZulu Natal), Ilembe District (KwaZulu Natal), uMgungundlovu District (KwaZulu Natal), Nkangala District (Mpumalanga)	OR Tambo District (Eastern Cape)	City of Johannesburg Metro District (Gauteng), Mopani District (Limpopo)	Pixley Ka Seme District (Northern Cape), Bojanala Platinum District (North West), Ngaka Modiri Molema District (North West)
2	Fezile Dabi District (Free State)	OR Tambo District (Eastern Cape)	Fezile Dabi District (Free State), Thabo Mofutsanyane District (Free State), Sedibeng District (Gauteng)	OR Tambo District (Eastern Cape)	Sedibeng District (Gauteng), Capricorn District (Limpopo), Mopani District (Limpopo), Vhembe District (Limpopo), Waterberg District (Limpopo), Dr. Ruth Segomotsi Mompati District (North West)
3	Thabo Mofutsanyane District (Free State), Sedibeng District (Gauteng)	Sedibeng District (Gauteng)	Nelson Mandela Bay Metro District (Eastern Cape), City of Ekurhuleni Metro District (Gauteng), City of Johannesburg Metro District (Gauteng), Ilembe District (KwaZulu Natal), Ugu District (KwaZulu Natal), uMgungundlovu District (KwaZulu Natal), uMzinyathi District (KwaZulu Natal), Uthukela District (KwaZulu Natal), Dr. Kenneth Kaunda District (North West)	ZF Mgcawu District (Northern Cape)	Fezile Dabi District (Free State), Mangaung Metro District (Free State), Xhariep District (Free State)

4	eThekwini Metro District (KwaZulu Natal)	Zululand District (KwaZulu Natal)	Ehlanzeni District (Mpumalanga)	Capricorn District (Limpopo)	Alfred Nzo District (Eastern Cape), OR Tambo District (Eastern Cape), Sekhukhune District (Limpopo)
5	Alfred Nzo District (Eastern Cape), Nelson Mandela Bay Metro District (Eastern Cape), uMgungundlovu District (KwaZulu Natal)	Fezile Dabi District (Free State), Thabo Mofutsanyane District (Free State), King Cetshwayo District (KwaZulu Natal), Uthukela District (KwaZulu Natal), Mopani District (Limpopo), Bojanala Platinum District (North West), Dr. Kenneth Kaunda District (North West), Ngaka Modiri Molema District (North West)	Buffalo City Metro District (Eastern Cape)	City of Ekurhuleni Metro District (Gauteng), King Cetshwayo District (KwaZulu Natal), Bojanala Platinum District (North West), Ngaka Modiri Molema District (North West)	Thabo Mofutsanyane District (Free State), John Taolo Gaetsewe District (Northern Cape), ZF Mgcawu District (Northern Cape)

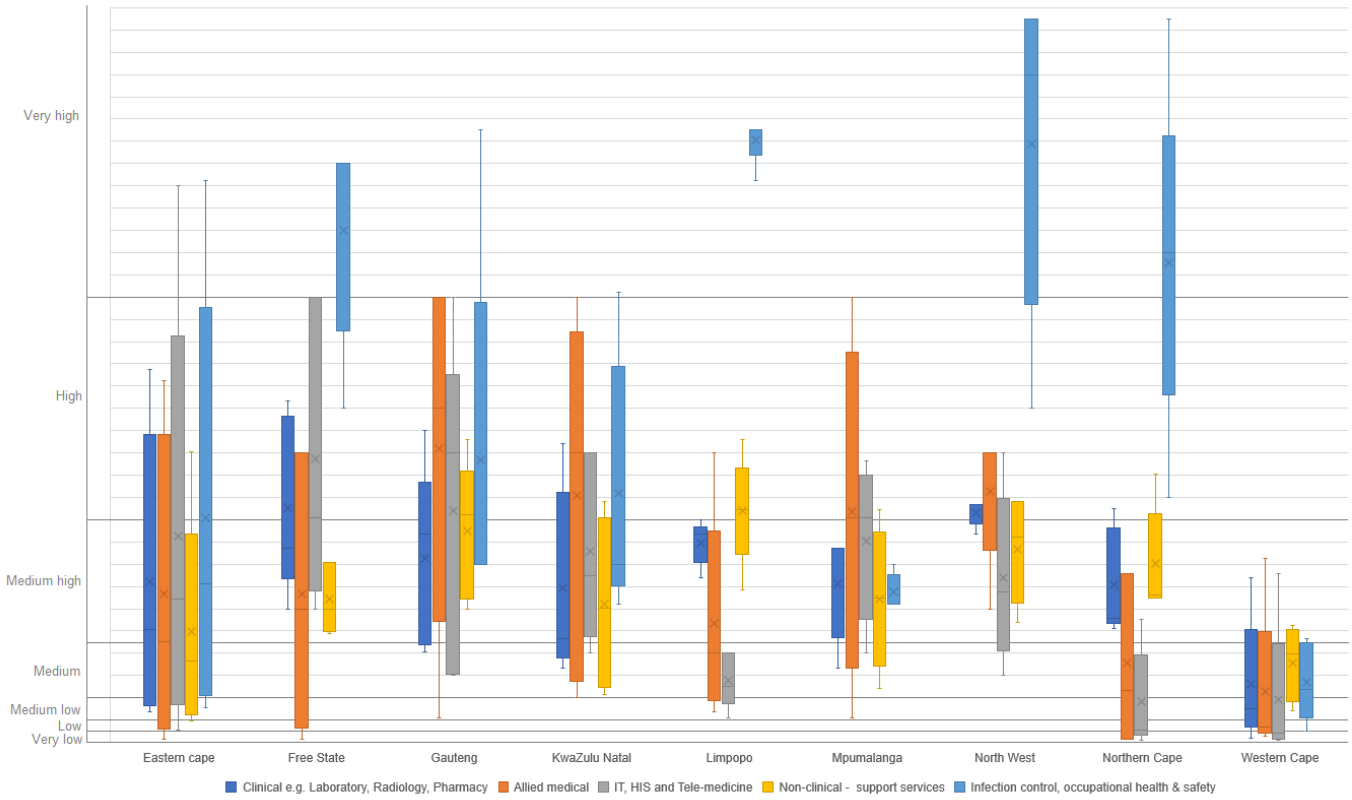
Table 53. Summarised Support Services Sub-Categories Ranking by Count of District Rankings

Rank:	Services (number of districts):
1st	Infection control, occupational health and safety (35)
2nd	IT, HIS, and tele-medicine (18), non-clinical support services (15)
3rd	Clinical (eg laboratory, radiology, and pharmacy) (28)
4th	Allied medical (16)

Table 54. Full Support Services Sub-Categories Ranking by Count of District Rankings

Rank	Clinical e.g. Laboratory, Radiology, Pharmacy	Allied medical	IT, HIS and Tele-medicine	Non-clinical - support services	Infection control, occupational health & safety
1st	0	11	5	3	35
2nd	9	10	18	15	4
3rd	28	3	5	12	3
4th	12	16	9	14	3
5th	3	12	15	8	7

Figure 12. Whisker Graph of the Support Services Category



Disease	Convergent	Divergent
Clinical (eg laboratory, radiology, pharmacy)	Table 54 demonstrates clinical is has the largest proportion of 3rd most at relative risk sub-category in the districts, with the next largest proportion being in 4th place. The national relative risk population is clustered between medium (17%), medium high (48%), and high (23%).	
Allied medical	Table 54 demonstrates allied medical has a wide distribution of ranks, however it has the largest number in the 4th most significant relative risk ranked sub-category in the districts, but also with a relatively large number of districts in 1st, 2nd, and 5th. The national relative risk rankings are distributed between medium low (15%), medium (13%), medium high (15%), and high (38%).	KZN, MP, NW, and WC have a higher percentage of districts where allied medical is the 1st, and 2nd most at risk sub-category, when compared to the national population.
IT, HIS, and tele-medicine	Table 54 demonstrates IT, HIS, and tele-medicine has the most districts with it as the 2nd most at relative risk sub-category, however the majority of districts fall into the 3rd, 4th, and 5th ranks. The national relative risk ranks are clustered at medium (27%), medium high (21%), and	LIM, and NC are outliers, as IT, HIS, and tele-medicine rank much lower compared to other sub-categories, when compared to the provinces' distribution. In both provinces IT, HIS, and tele-medicine ranks in either 4th of 5th most at risk sub-category.

	high (31%).	
Non-clinical support services	From Table 54 non-clinical support services can be seen to be distributed between 2nd 3rd, and 4th ranks, which the largest proportion in the 2nd rank. The national relative risk ranks are clustered at medium (15%), medium high (52%), and high (23%).	The FS is an outlier as non-clinical support services is at a lower relative risk to other subcategories when compared to other provinces distributions. LIM is an outlier as non-clinical support services ranks higher compared to other sub-categories relative risk values, when compared to other provinces distributions.
Infection control, occupational health and safety	Table 54 demonstrates that infection control, occupational health and safety is the sub-category at the highest level of risk compared to other sub-categories, with only a limited distribution across the lower rankings. Infection control, occupational health and safety relative risk rankings are clustered around medium high (35%), high (13%), and very high (38%).	LIM, NC, and NW are outliers in the sense that their infection control, occupational health and safety relative risk values are so much higher than other sub-categories, when compared to other provinces distributions. By contrast MP is an outlier as infection control, occupational health and safety ranks far lower compared to the other sub-categories, when compared to other provinces distributions.

Appendix 3: Health maps – attached separately