Surveillance for communicable diseases is the first and most important step in addressing public health challenges. Surveillance initiates awareness of the magnitude of public health problems, provides evidence for advocacy and action, facilitates accurate planning for service delivery and allows for monitoring of the impact of interventions. In-country disease surveillance programmes are a stipulated component of the International Health Regulations (2005), to which South Africa is a signatory.

This chapter outlines epidemiological trends for a spectrum of communicable diseases affecting the South African public, thus allowing assessment of the impact of health interventions.

The findings support the need for ongoing human and financial resources. The National Public Health Institutes of South Africa Bill will broaden the range of conditions under surveillance by including non-communicable disease, environmental health and injury and violence prevention. This will ensure that these growing public health threats and interventions to ameliorate their impact, are monitored.
Introduction

Surveillance for communicable diseases is the first and most important step in addressing public health challenges. Surveillance initiates awareness of the magnitude of public health problems, provides evidence for advocacy and action, facilitates accurate planning for service delivery and allows for monitoring of the impact of interventions. In-country disease surveillance programmes are a stipulated component of the International Health Regulations (2005), to which South Africa is a signatory.

The National Institute for Communicable Diseases (NICD) was created as a division of the National Health Laboratory Services (NHLS) through the amalgamation of the South African Institute for Medical Research (SAIMR) and the National Institute for Virology (NIV) by the National Health Laboratory Services Act in 2000 (Act 37 of 2000). Over time, the work of the NICD was re-orientated towards addressing public health challenges related to communicable diseases. Seven specialist reference centres within the NICD were created to take responsibility for specific organisms or clinical syndromes. The Division of Public Health Surveillance and Response (DPHSR) was created to house the Outbreak Response Unit (ORU), Provincial Epidemiology team (PET), the National Notifiable Diseases Surveillance Unit and the Field Epidemiology Training Programme (FETP). The NICD took on a public health surveillance focus including the ongoing collection, analysis and interpretation of communicable disease data, monitoring for the emergence of infectious diseases, outbreak investigation and management, and conducting research directed towards addressing regionally relevant communicable disease challenges.

The major health problems in South Africa remain the HIV and TB epidemics, which directly and indirectly, contribute significantly to premature death and morbidity. This dual outbreak of communicable disease further increases vulnerability to other prevalent communicable diseases, which in total account for 38% of deaths among under fives, and just under 40% of deaths in adults aged 15–45 years.1 The NICD is uniquely positioned to document impact of health interventions on communicable disease, and so progresses towards the goals of the National Development Plan 2030. We provide an overview of major surveillance activities initiated and supported by the NICD. These activities contribute to addressing priority disease conditions and illustrate the crucial role of surveillance in documenting the impact of health policy and interventions on public health outcomes.

Surveillance methodology, data management and analysis.

A number of different methodologies are employed by the NICD to meet surveillance objectives, the details of which are provided in references cited and on the NICD website (www.nicd.ac.za). These are:

- secondary analysis of laboratory diagnostic data obtained through the NHLS from the central data warehouse (CDW);
- laboratory-based surveillance complemented in sentinel sites with retrieval of clinical data by patient record review with or without patient interview;
- syndromic surveillance in selected sentinel sites;
- notifiable medical conditions surveillance;
- sero-prevalence surveys;
- event-based surveillance through the NICD 24-hour hotline; and
- disease vector surveillance.

Each NICD Centre manages data independently. Where surveillance activities require patient interview or medical record review, data is collected by surveillance officers using paper or electronic case investigation forms. Electronic real-time on-site data entry is supported by external service providers. NICD Centres maintain independent MS Access databases, and assume responsibility for data cleaning. Analysis of surveillance data is highly specific to each disease or condition under surveillance.

Surveillance for communicable diseases

Tuberculosis

The NICD Centre for Tuberculosis (CTB) conducts surveillance and microbiology reference tests to monitor and inform the epidemiological landscape of TB and drug-resistant TB in South Africa (SA). In turn, surveillance data supports the development of TB control programme goals, determination of appropriate treatment regimens for drug-sensitive and drug-resistant TB, and other interventions. An analysis of NHLS TB diagnostic data between 2004 and 2012 demonstrated a 9% decline in microbiologically confirmed pulmonary tuberculosis (mPTB) incidence from 2008 to 2012 (848 cases/100 000 (95% confidence interval (CI) 845–850) to 774 cases/100 000 (CI 771–776)).2 This analysis was updated in 20152 demonstrating a continued annual reduction in the national year-on-year mPTB incidence of 4.1%, 6.0% and 4.8% for the years 2013, 2014 and 2015 compared with each previous year, respectively (Figure 1). Although this reduction was only half of what was required by the Millennium Development Goals, it exceeds the global average year-on-year reduction of between 1% to 2%.

In 2012–2014, the NICD together with the National Department of Health (NDoH) conducted the largest ever drug-resistant TB survey globally. Over 100 000 patients were enrolled and tested for drug-resistant TB.3 Surveillance findings confirmed that the prevalence of multi-drug resistant TB (MDR-TB) was stable (2.8%, (95% CI 1.5–2.7) compared to the previous survey conducted in 2001–2 (2.9%, 95% CI 2.4–3.5%)); and lower relative to that reported globally (7.7%). The survey identified a doubling of resistance rates to rifampicin, the main drug for TB treatment (from 1.8% to 3.4%) in patients without any previous history of TB treatment. This indicates primary transmission of drug resistant TB and supports the use of Xpert MTB/Rif as the first line diagnostic assay for detection of TB and rifampicin resistance. The survey also identified a high prevalence of second line drug resistance among those cases with MDR-TB. The prevalence of extensively drug-resistant TB (XDR-TB) was determined to be 4.9% of all MDR cases, which is in line with the global average.
Communicable diseases

HIV surveillance

The NICD Centre for HIV and Sexually Transmitted Infections (CHIV&STi) co-ordinates and conducts HIV surveillance amongst infants and children, pregnant women, and surveillance for HIV drug resistance amongst persons initiating antiretroviral therapy (ART). These surveillance programmes are important data sources for programme development, determining ART regimens, target setting, monitoring of service delivery and statistical modelling of the HIV epidemic. Secondary data analysis of NHLS HIV DNA polymerase chain reaction (PCR) test results, conducted as part of the prevention of mother-to-child transmission (PMCT) programme has demonstrated a reduction in mother-to-child transmission (MTCT) rates. In 2006, MTCT of HIV resulted in at least 17% of infants testing HIV positive at six weeks. With aggressive clinical treatment, comprehensive management and a supportive laboratory testing programme, PMCT transmission rates are now <2%. Validation of this methodology has been demonstrated through analysis of three independent data sources all of which provide very similar MTCT rate estimates.

The NICD has conducted the National Annual HIV and Syphilis antenatal seroprevalence survey collaboratively with the NDoH and other stakeholders since 1990, but took on full responsibility for the survey in 2017. The survey indicates that HIV prevalence has remained relatively stable over the last 10 years of the survey (Figure 2).

The CHIV&STi has conducted retrospective seroprevalence surveys, sentinel site and localised HIV drug resistance (DR) surveillance since 2005. Retrospectively analysed serum from the national antenatal seroprevalence survey specimens obtained 2005–2009 indicated that transmitted drug resistance was <5% in Gauteng Province (GP) for all drug classes, and between 5–15% in KwaZulu-Natal Province (KZN) for non-nucleoside reverse transcriptase inhibitors. In 2014, in KZN, fewer than 8% of adult patients were failing first-line ART up to 3 years post-ART initiation. By the end of 2017, data from 6 provinces has shown a rate of 15% resistance to non-nucleoside reverse transcriptase inhibitors.

Figure 2: National Annual HIV prevalence in pregnant women according to the national antenatal sentinel HIV prevalence survey, South Africa, 1990–2015.

Cryptococcosis

The NICD Centre for Hospital-acquired infections, Antimicrobial resistance and Mycoses (CHARM) conducts active laboratory-based surveillance for cryptococcosis to inform policy regarding prevention and early detection. Since 2005, 85 969 new cases were detected, the vast majority (95%) with cryptococcal meningitis. The national annual incidence rate has declined by 44% from a peak of 162 cases per 100 000 HIV-infected persons in 2006 to 90 cases per 100 000 in 2015 (Figure 3). The incidence rate of cryptococcosis in 2015 was below that observed in pre-ART era. In response to the high burden of disease, CHARM together with the NHLS, NDoH and other partners, initiated a national laboratory-based cryptococal antigen (CrAg) screening programme aimed at detecting early cryptococcal disease before progression to meningitis in all HIV-seropositive patients with a CD4 count <100 cells/µL in 2016.10

From October 2016 to September 2017, 276 125 patients were screened and 15 757 (5.7%) were identified with cryptococcal antigenaemia. This indicated the potential for development of life-threatening cryptococcosis, and the need for urgent preventive fluconazole therapy. The NICD is leading ongoing programme evaluations and is working with partners to enhance the clinical impact of the programme.

Sexually transmitted infection (STI) syndromes

The NICD CHIV&STi conducts surveillance for sexually transmitted infections to ensure that the syndromic treatment guidelines respond to epidemiological changes in disease aetiology, and remain effective at patient and population levels. Syndromic surveillance for STIs at primary healthcare facilities in four South African provinces during the period 2014–201611 showed that Neisseria gonorrhoeae remained the predominant cause of male urethritis syndrome (MUS). During the period under surveillance, the prevalence of high-level resistance in N. gonorrhoeae increased from 30% to 51% for penicillin (p-value for trend < 0.001), 75% to 83% for tetracycline (p-value for trend = 0.008), and 25% to 69% for ciprofloxacin (p-value for trend < 0.001). Chlamydia trachomatis was the second most commonly isolated pathogen. Antimicrobial therapy covering both pathogens is therefore appropriate. However, the high prevalence of penicillin, tetracycline, and ciprofloxacin resistance in N. gonorrhoeae obviates their use in future national treatment algorithms for genital discharge. Surveillance showed that herpes simplex virus was the commonest detectable cause of genital ulceration, supporting the continued use of acyclovir in syndromic management. Surveillance identified a high HIV seroprevalence among patients with STI, underscoring the need for HIV counselling and testing amongst persons with STI.

Diseases preventable through the Expanded Programme of Immunisation

Polio and acute flaccid paralysis

The NICD Centre for Vaccines and Immunisation (CVI) together with the NDoH and district health department surveillance teams collectively support surveillance for acute flaccid paralysis (AFP), which is the cornerstone of polio eradication efforts. South Africa has been free of wild poliovirus since 1989. The non-polio AFP detection rate in South Africa in 2017 was 2.3 cases/100 000 under 15 years of age in 2017,12 lower than the 2016 level of 3.0. The detection rate reaches the WHO target of 2.0/100 000 but not the heightened 2015 country target of 4.0/100 000. Surveillance performance needs to be strengthened.

Diphtheria

The NICD Centre for Respiratory Disease and Meningitis (CRDM) conducts event-based surveillance for diphtheria. During 1980–2014, a total of 412 diphtheria cases were reported in South Africa with most (>80%) notified before 1990.13 In 2015, an outbreak of respiratory diphtheria occurred in two health districts in KZN.14 Fifteen cases of diphtheria were identified, with ages ranging from 4 to 41 years with a case fatality of 27%. Nine/12 cases (75%) under the age of 18 years were not fully immunized for diphtheria. Subsequently two laboratory-confirmed cases were identified in

Figure 3: Incidence of laboratory-confirmed cryptococcosis (cases/100 000 general population) and the proportion of the HIV-positive population receiving antiretroviral treatment (ART), South Africa, 2005–20159
KZN in 2016, 4 from the Western Cape Province (WC) in 2017, and 4 from KZN in 2018. The majority of cases occurred in children over the age of 6 years. These data indicate the need to strengthen primary and booster immunisation coverage, particularly at 6 and 12 years.

Invasive pneumococcal disease

CRDM conducts surveillance for invasive pneumococcal disease (IPD) to monitor the impact of the pneumococcal conjugate vaccine. The 7-valent pneumococcal conjugate vaccine (PCV-7) was introduced in the South African expanded programme of immunisation (EPI) in April 2009 and was replaced by the 13-valent pneumococcal conjugate vaccine (PCV-13) in 2013. The vaccine reduced the incidence of IPD by 79% in children younger than five years, from 30 per 100 000 population in 2005 to 6 per 100 000 per population in 2017 (Figure 4). The vaccine also reduced IPD by 46% in persons aged five years and older, from 7 per 100 000 population in 2005 to 4 per 100 000 per population in 2017. Cases of IPD are mostly due to serotypes not included in PCV-13.

Invasive Haemophilus influenzae type b disease

CRDM conducts surveillance for invasive Haemophilus influenzae type b (Hib) disease to monitor the impact of the Hib conjugate vaccine, introduced in 1999. Surveillance demonstrated that Hib disease in children <1 year of age decreased by 65% from 1999–2004. From 2004–2010 the surveillance programme noted an increase in disease driven by vaccine failures in older children and HIV-coinfection. A Hib vaccine booster dose at 18 months was implemented into the EPI schedule in November 2010. Subsequently the incidence of Hib in children <1 year of age decreased by 69%, from an incidence of 5.2 cases per 100 000 population in 2010, to 1.6 cases per 100 000 population in 2017 (Figure 5).
Rotavirus
The Centre for Enteric Diseases (CED) conducts surveillance for rotavirus and all-cause diarrhoea to monitor the impact of the rotavirus vaccine, to detect seasonal trends and the aetiology of diarrhoeal disease. Surveillance demonstrated a sustained reduction in diarrhoeal disease due to rotavirus and all-cause diarrhoeal disease in children <5 years in South Africa following the introduction of the rotavirus vaccine into the EPI in August 2009.20 In 2014 and 2015 surveillance findings demonstrated lower rotavirus prevalence and reduced absolute numbers of hospitalized diarrhoea cases in children <5 years compared to 2008. Surveillance has also shown that protection afforded by the rotavirus vaccine is not complete and that annual rotavirus seasons from May-September affecting mostly children <2 years, should be expected.

Measles
CVI together with the NDoH and district health departments surveillance teams conduct surveillance for measles to support the WHO campaign to eliminate measles by 2020, and to detect cases, identify vaccine coverage gaps, monitor the impact of routine vaccination and advise on the need for supplementary immunisation activities. South Africa experienced a major measles outbreak in 2009–10 with over 18 000 laboratory-confirmed cases identified.21 Seventeen and 14 cases of measles were confirmed in 2015 and 2016 respectively. In 2017, 210/6 256 (3%) suspected-measles cases were laboratory-confirmed.22 Currently, the national measles incidence rate per million is 3.7, exceeding the World Health Organization’s 2020 elimination target of <1 per million population.

Epidemic-prone diseases
Influenza
CRDM conducts surveillance for influenza-like illness (ILI) to detect seasonal patterns of disease, determine circulating vaccine strains, monitor disease severity and vaccine effectiveness. Data contributes to global vaccine development and surveillance, and supports national vaccine utilisation campaigns. Sentinel surveillance is conducted by general practitioners in private practice since 1984, in primary health clinics since 2012 and in public hospitals since 2009. Surveillance indicates that the average onset of the influenza season over the past 33 years is the first week of June23 but has commenced between mid-April to the first week of July. The average duration of the influenza season is 14 (range 7–18) weeks. The temporal distribution of influenza strains and the detection rate since 2009 are shown in Figure 6. During the influenza season, approximately 14% of inpatients with lower respiratory tract infection and 25% of outpatients with influenza-like illness will test positive for influenza. Surveillance programmes played a critical role in monitoring the emergence of pandemic influenza A(H1N1) 2009 virus during 2009.24

Figure 6: Results from surveillance for pneumonia (severe acute respiratory syndrome) at public health clinics in five South African provinces, 2009–2018 showing the number of respiratory specimens positive for influenza by types and subtypes, and by detection rate per week

Source: Centre for Respiratory Disease and Meningitis, NICD.

Invasive meningococcal disease
CRDM conducts laboratory-based surveillance for invasive meningococcal disease (IMD) to monitor epidemiological trends and support outbreak and prevention activities. Surveillance has demonstrated a decline in cases from 2003–2017 by 76% from 1.0 to 0.2 per 100 000 population, and the emergence of serogroup W in South Africa in 2005/6.25 The highest incidence of IMD is in children <1 year of age (2.2 per 100 000 population in 2017) (Figure 7). The case-fatality ratio for IMD was 17%. South Africa experiences IMD from multiple serogroups but the majority of cases are serogroup B followed by W, Y and C.
Salmonella Typhi

CED conducts surveillance activities for laboratory-confirmed typhoid to support prevention and control efforts. Findings from 2005–2018 demonstrate that typhoid fever remains endemic in South Africa at low levels (<150 cases/year, Figure 8) with localised clusters of cases mainly due to endemic strains. A larger outbreak occurred in 2005–2006 in Mpumalanga Province (MP) associated with contaminated water. Imported travel-related cases are reported, particularly in 2017 following an outbreak in Harare, Zimbabwe.

Vibrio cholerae

CED conducts event-based surveillance for cholera. A large outbreak of cholera was detected and controlled in Limpopo Province (LP) in 2008–2009 with 1,003 laboratory-cases identified. Sporadic cholera cases have been detected and reported (1 in 2011, 1 in 2013, 2 in 2014, 5 to date in 2018), allowing for early implementation of appropriate community and public health activities.
Food-borne illness including listeriosis

Food-borne diseases

CED supports the NDoH, provincial and district health departments to investigate food-borne disease (FBD) outbreaks. 327 FBD outbreaks were reported to the NICD over the period January 2013 to December 2017. These outbreaks caused illness in 11,155 individuals, with 8,680 hospital visits, 494 hospital admissions and 49 deaths. Salmonella species was the most commonly identified aetiology identified in stool (29/147, 19.7%) and food (15/132, 11.4%) samples.

Listeriosis

CED supports listeriosis outbreak investigation and, since 2017, conducts surveillance to detect and investigate clusters of cases using whole genome sequencing. Prior to December 2017, listeriosis was not notifiable. Review of private and public laboratory diagnostic data from 2013–2016 revealed an average of 60 to 80 laboratory-confirmed listeriosis cases per year (approximately 1 per week). From July 2017 until August 2018, a nationwide outbreak of listeriosis occurred (Figure 9) with over 1,060 laboratory-confirmed cases and 216 (27%) deaths amongst 806 cases where outcome was known. The source of the outbreak was identified as ready-to-eat processed meat from the Enterprise Foods’ Polokwane production facility. A recall of affected products was initiated on 4 March 2018, which effectively controlled the outbreak.

Zoonoses

Malaria

The Centre for Emerging, Zoonotic and Parasitic Diseases (CEZPD) conducts surveillance for malaria vectors, insecticide resistance and malaria parasite drug resistance to monitor the distribution of vectors, the effectiveness of the malaria control programme, and to inform national antimalarial drug policy. Vector surveillance during 2017 revealed the presence of three malaria vector species – Anopheles arabiensis, An. merus and An. vaneedeni – which have previously been shown to contribute to ongoing residual malaria transmission in South Africa. Most of the specimens analysed were collected from MP (46.8%) and KZN (32.2%) with smaller proportions collected from LP (10.2%) and the Kruger National Park (10.8%). The surveillance information identified that vector control based on indoor residual spraying (IRS) needs to be maintained at a high rate of coverage and should be completed before the onset of each malaria season.

Viral haemorrhagic fevers

CEZPD conducts event-based surveillance for cases of viral haemorrhagic fevers (VHF) including Ebola virus disease (EVD) and Crimean-Congo haemorrhagic fever (CCHF). No cases of EVD were imported to South Africa during the recent West African outbreak. CEZPD deployed a Field Ebola Diagnostic Laboratory (FEDL) to Freetown, Sierra Leone between August 2014 and June 2016. During the operation, the laboratory tested 11,256 specimens from suspected EVD cases, of which 2,379 were positive. South Africa is endemic for CCHF (Figure 10) and fewer than 10 cases are diagnosed annually. The NICD played a critical role in the investigation, diagnosis and control of a nosocomial disease outbreak of a newly-discovered agent of VHF, the Lujo arenavirus (“Lusaka-Johannesburg”virus) in 2008. The index case was transferred from Lusaka, Zambia, to Johannesburg for medical management. Nosocomial transmission to four patients (three secondary cases and a single tertiary case) occurred.
Communicable diseases

Rabies

CEZPD conducts event-based surveillance for rabies to support veterinary public health efforts to control canine rabies, development of guidelines for rabies prevention and health promotion strategies. Since 1983, 456 human cases of rabies have been laboratory-confirmed (Figure 11).

Antimicrobial resistance and hospital-acquired infections

CHARM conducts surveillance for antimicrobial resistance and hospital-acquired infections in support of global and national and facility efforts to monitor, control and prevent the emergence of antimicrobial resistant infections. Surveillance for Staphylococcus aureus was conducted from 2010 until 2017 indicating that 92% of MRSA cases are healthcare-associated MRSA (HA-MRSA) bacteraemia, and 8% are community-associated (CA-MRSA). Laboratory-based enhanced surveillance for carbapenem-resistant Enterobacteriaceae (CRE) has been ongoing since 1 July 2015 using the GERMS-SA platform. Surveillance has demonstrated an increase of these highly-resistant organisms which has major consequences for patient outcomes and healthcare costs. The NICD has developed an internet based ‘dashboard’ to facilitate awareness of these resistant organisms at hospital, district and provincial levels. Through surveillance for invasive fungal infections, CHARM has documented outbreaks of candidaemia at sentinel hospitals and identified that the newly-emerged and multi-drug resistant Candida auris is a major healthcare-associated pathogen in South Africa.

National Public Health Institute of South Africa (NAPHISA) and beyond – the way forward regarding surveillance for communicable disease

This chapter has provided an overview of the major surveillance activities conducted by the NICD together with the NDoH and district health departments over the last decade. Findings demonstrate the effectiveness of major health interventions including the provision of new and improved vaccines (against Haemophilus influenzae type B, Streptococcus pneumoniae) and antiretroviral therapy. Further, these surveillance activities have contributed immeasurably to strengthening of health systems through provision of data for action, monitoring progress towards targets, planning for service delivery and resource allocation.

The burden of non-communicable disease, including morbidity and mortality due to environmental and occupational harms, injury and violence in South Africa is increasing. Surveillance for these conditions is essential if South Africa is to meet targets of the National Development Plan 2030 (NDP) – specifically an increase...
in life expectancy to 70 years at birth. In support of this, and also in line with international trends, the Parliamentary Portfolio on Health tabled the National Public Health Institute of South Africa (NAPHISA) Bill in 2017. The Bill will broaden the activities of the NICD through the inclusion of public health monitoring activities that focus on non-communicable diseases and conditions. This will ensure that these growing public health threats and interventions to ameliorate their impact, are monitored.

At a policy and political level, sustained support for the NICD over the last 18 years has ensured that the human and financial resources necessary to achieve its mission and aims have been provided. The achievements in surveillance activities underscore the integral role of the NICD in providing surveillance data to monitor health interventions. Further, these achievements identify the value of the NICD as a national asset in preserving and monitoring the health and vitality of the South African public.

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References


