

HRH planning for rehabilitation services:

a focus to reduce inter-provincial inequities

Authors

Ritika Tiwariⁱ
Lieketseng Nedⁱⁱ
Usuf Chikteⁱ

Availability of rehabilitation therapists (in optimum numbers) will play a crucial role in safeguarding and ensuring universal health coverage for the population of South Africa.

Public sector rehabilitation workforce planning and policy implementation in South Africa are inadequate, and the impact of this is reflected in critical human resource shortages, maldistribution of these resources, and limited access to quality healthcare services. This chapter estimates human resource gaps and projects the additional need from 2020 to 2030 for three rehabilitation therapist categories, namely occupational therapists; speech therapists and audiologists; and physiotherapists. An equity-based health workforce planning approach was used to reduce existing inter-provincial inequities, with a view to attaining horizontal equity by 2030. To keep estimates realistic, two scenarios were created, one based on past historical trends, and the other assuming zero per cent growth for the respective professions in the public sector. The 2019 Personnel and Salary System (PERSAL) database and South African

uninsured population statistics were used to generate rehabilitation therapist/population ratios, and to rank provinces and analyse inter-provincial inequity.

A four-pronged strategy is proposed to meet the critical shortage of rehabilitation therapists in South Africa. This strategy involves the re-introduction of formalised training for profession-specific mid-level workers; formalised training of community-based rehabilitation workers done collaboratively by departments of health, social development and education; the creation of posts and improved deployment of trained professionals; and strengthening and expansion of the national training capacity for rehabilitation therapists through widening access and increasing the number of enrolments in higher education institutions.

i Department of Global Health, Division of Health Systems and Public Health, Stellenbosch University
ii Centre for Disability & Rehabilitation Studies, Department of Global Health, Stellenbosch University

Introduction

Public domain rehabilitation workforce planning in South Africa is inadequate,^{1,2} and the impact of this is reflected in critical shortages of human resources, maldistribution of these resources, and inequitable access to quality healthcare services. Previous health workforce projections for South Africa's public sector needs generated in 2011³ did not specifically address the provision of rehabilitation services for persons with disabilities. The World Report on Disability drew attention to the inadequacy of the rehabilitation workforce globally and highlighted that many countries do not include rehabilitation in their national planning and reviews of human resources for health (HRH).⁴

The World Health Organization (WHO) report, *Rehabilitation 2030: A Call for Action*, recognised the growing need for rehabilitation worldwide, with demand for services far exceeding the availability of human resources.⁵ A global study on supply of and need for HRH-related rehabilitation services showed that 92% of the global burden of disease is

associated with impairment, adds to the disability burden, and requires rehabilitation support.⁶ Persons with disabilities are defined by the United Nations Convention on the Rights of Persons with Disabilities (UN CRPD) as "those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others".⁷ It has been estimated that 15% of the total population experience some form of disability and are in need of rehabilitation services, with the majority of this population located in the Global South.⁴

Within South Africa, the paucity of rehabilitation workers has been highlighted as a barrier in implementing disability and rehabilitation plans, and as hindering improved access to these services.^{1,8-11}

Disability rates in the country have been reported to vary from 4.4% to 7.7% and 16.1%. Table 1 below provides an overview of disability measures, disability rates, and domains of functioning.

Table 1: Disability measures, disability rates, and domains of functioning

Disability measure	Disability rates in South Africa	Six domains of functioning: ¹² Seeing Hearing Communicating Walking Remembering and Self-care
Disability measure 1	4.4%	Measure 1 is a broad disability measure that includes all persons aged five years and older who reported "some difficulty" in any of the domains of functioning, and "a lot of difficulty" and "cannot do at all" in any of the six domains of functioning.
Disability measure 2	7.7%	Measure 2 refers to the UN disability index that includes all persons aged five years and older who reported "some difficulty" in at least two domains of functioning, and "a lot of difficulty" and "cannot do at all" in any of the six domains of functioning.
Disability measure 3	16.1%	Measure 3 is a severe disability measure that includes all persons aged five years and older who reported "a lot of difficulty" and "cannot do at all" in any of the six domains of functioning.

In 2018, the UN published a flagship report focused on realisation of the Sustainable Development Goals by, for, and with persons with disabilities. It was noted that access to rehabilitation services remains a major challenge, with more than 50% of persons with disabilities having an unmet need for rehabilitation services.¹³

Another important category of health worker providing rehabilitation services within the broader team, is the mid-level worker (MLW). MLWs generally receive fewer and shorter periods of training and have a narrower scope of practice than professionally qualified rehabilitation therapists (RTs). There are both discipline-specific MLWs and generic MLWs. In contrast to community health workers, MLWs have a formal certificate/accreditation through their

countries' licensing bodies.¹⁴ It has been observed that MLWs improve access to and coverage of health services, including rehabilitation.¹⁴ Evidence suggests that MLWs play a role in strengthening access to health services.^{15,16}

In 2015, the National Framework and Strategy for Disability and Rehabilitation (FSDR) was developed in South Africa to integrate disability and rehabilitation services within priority healthcare programmes at all levels of the system.¹⁷ One of the goals of this framework is to develop and implement an HRH plan for disability and rehabilitation services. Ideally, the core rehabilitation team should include a physiotherapist (PT), an occupational therapist (OT), a speech therapist (ST), an audiologist, a medical orthotist and prosthetist (MOP), and related MLWs.¹⁸ Comprehensive rehabilitation services should be inclusive of both generic and discipline-specific MLWs. However, PTs, OTs, and speech therapists and audiologists (STAs) are the most common available providers of rehabilitation services in South African healthcare settings.¹⁸

The FSDR 2015-2020 shows a vacancy rate of 22-27% in rehabilitation fields in the public sector, with a total of 1 213 posts filled by OTs, 1 256 by PTs, and 596 by STAs. There is also an unequal distribution of these professional categories across provinces.¹⁷ Apart from limited funded posts available, other studies show poor retention or absorption of these professionals in the public sector.^{19,20} Human resource planning and priority setting for rehabilitation services in South Africa are in need of considerable improvement. Given the persisting quadruple burden of disease with associated impairments, and an increasing ageing population, there is a need to redistribute funding in order to increase rehabilitation staff in communities where rehabilitation is most needed.

The aim of this chapter is to estimate gaps and project additional need from 2020 to 2030 for the three RT categories (PTs, OTs, and STAs) in the public sector using an equity-based HRH planning approach to reduce existing inter-provincial inequities. A multi-pronged strategy was used to accomplish this. Ethical approval and a request for waiver of informed consent for this retrospective study was obtained from the Stellenbosch University Health Research Ethics Committee (HREC Reference No: X19/03/007).

HRH projections

Evaluating the current stock of RTs

The current stock of the three core RT categories employed in the public sector was evaluated using the Personnel and Salary System (PERSAL) database.²¹ The PERSAL data were obtained from the National Treasury aggregated health worker headcounts for each quarter from 2002 to 2019. The data were used to estimate whether the current stock of RTs was sufficient for national needs. The (wo)manpower-to-population ratio approach was used in this exercise (which depends on the supply, distribution, and health workforce-to-

population ratios), the shortfall was estimated, and strategies were identified for correcting the course of action.²²

Setting benchmarks

Since the analysis focused mainly on the public sector's core rehabilitation workforce, it was assumed that the public sector user population would be proportional to the population without health insurance. As estimated in the 2018 National General Household Survey, only 16.5% of the national population have some health insurance cover.¹² Thus it was estimated that 83.5% of the population does not have health insurance and relies primarily on the public sector health service. The Thembisa model was used to make population estimates as it is the mathematical model for the South African HIV epidemic.²³

HRH norms were available from different sources, as well as HRH density per population for different countries.^{24,25} However, these data are not standardised according to lower-middle-income countries, or benchmarked on the basis of RT per 100 000 population (as in different populations in South Africa).

The nine provinces were ranked and divided into three tertiles.

Growth scenarios

In order to make future projections, growth scenarios were developed on the basis of historical trends. The following two scenarios were created:

The historical trend scenario assumes that the average growth rate experienced in the three years from 2017 to 2019 will continue to 2030. The annual growth in number of rehabilitation practitioners was extrapolated using an advanced Microsoft Excel model from the year 2020 to 2030, applying exponential smoothing. The exponential-smoothing technique utilises a time-series forecasting method for univariate data that can be extended to support data with a systematic trend or seasonal component.²⁶

The no-growth scenario assumes that at 2019 levels, the number of RTs in each category would be constant to 2030. As such, a growth of 0% per annum was assumed over the period from 2019 to 2030.

The future gap was estimated for each RT category using these two growth scenarios compared with four identified equity-targets (ratios).

Equity targets

In order to reduce the existing HRH inequity between South African provinces, four target ratios were created focused on attaining horizontal equity by 2030 (Figure 1):

- Status quo: RT population ratios are maintained at 2019 levels in each province.
- Sixth ranked province: RT population ratios are improved in the three last provinces in the last tertile

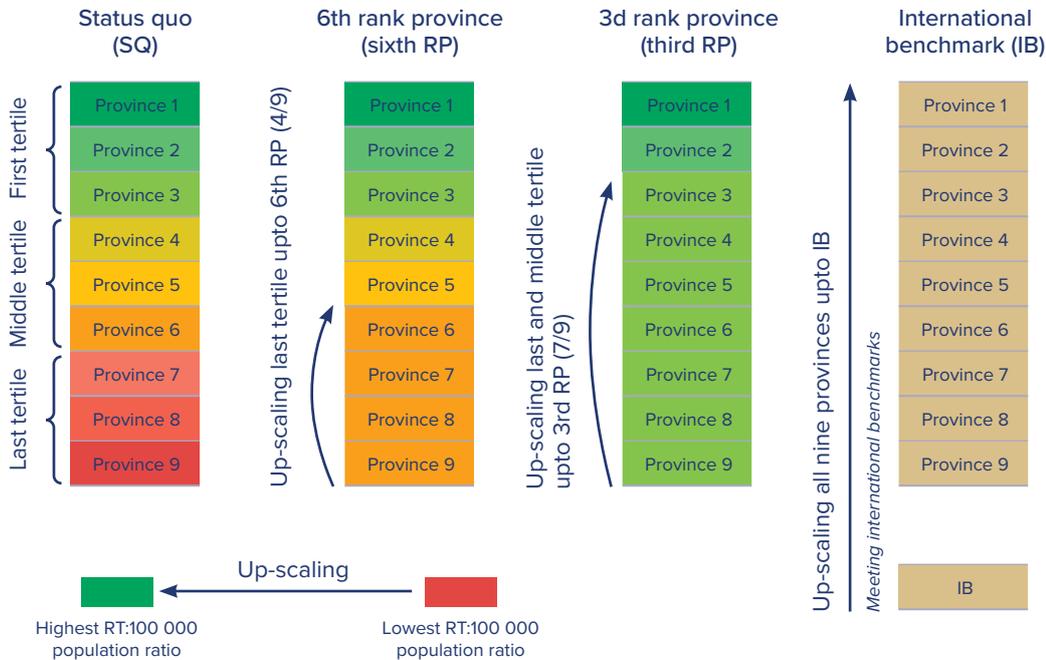
(ninth, eighth and seventh rank) to the level of the sixth ranked province, and ratios in the top six provinces are maintained at 2019 levels.

- Third ranked province: RT population ratios are improved in the six last provinces, i.e. in the last and middle tertile (ninth, eighth, seventh, sixth, fifth and fourth rank) to the

level of the third ranked province, and ratios in the top three provinces are maintained at 2019 levels.

- International benchmark: RT population ratios for all nine provinces are improved to the identified international benchmark level.

Figure 1: Equity targets set up to reduce existing inter-provincial inequities



Gap estimation

Workforce projections for the historical-trend and no-growth scenarios were compared with four different equity target ratios based mainly on improving the rehabilitation worker densities in the lowest-scoring provinces. The shortfall and additional public-sector budget were then forecast for the three RT categories required to up-scale the number of health professionals and achieve the equity targets, i.e. from the last tertile to the middle tertile and ultimately to the first tertile.

The analyses were done individually for the three RT categories identified above and then individually per category for each province before being aggregated to produce the national totals.

Key findings

Current stock of rehabilitation workers

In South Africa, there were 3 513 RTs in 2019, as per the extracted headcounts of public sector employees for OTs, PTs and STAs (Table 2). Of these, PTs (42.8%) constitute most of the workforce, followed by OTs (36.4%) and STAs (20.8%).

Table 2: South African public sector RTs (select categories), national numbers and density per 100 000 public sector population, 2019

Rehabilitation therapists	Numbers	Percentage	National density
Physiotherapists	1 504	42.8	3.10
Occupational therapists	1 279	36.4	2.64
Speech therapists & audiologists	730	20.8	1.51
Total rehabilitation therapists	3 513	100	7.25

Source: PERSAL.²¹

The national density of OTs, STAs and PTs was estimated to be 2.64, 1.51 and 3.10 respectively per 100 000 public health sector population (Table 2). Overall, there are 7.25 RTs per 100 000 public sector population.

Historical trends

Figure 2 shows the ratio trends for the three RT categories over the period 2002-2019.

Figure 2: Historical trends in public sector RT ratios per 100 000 uninsured population, 2002-2019



Source: PERSAL.²¹

Population: Calculated using the Thembisa model²³ and the StatsSA General Household Survey.¹²

Overall, there have been improvements in public sector staff-to-population ratios for the three RT categories over the last two decades. These results indicate that the number of RTs employed in the public sector has been increasing at a higher rate than the population growth rate. For example, the number of public sector OTs increased at an average of 11.1% annually, STAs at a rate of 25.4% per annum, and PTs at 12.1% per annum during the period 2002-2019, while the public sector population increased by 1.5% annually over the same time period.

Staffing ratios

The availability of RTs per 100 000 public sector population was estimated province wide as well as nationally. Of the three professionals, PTs had the highest ratios at 3.10 per 100 000 public sector population, followed by OTs at 2.64 and STAs at 1.51 per 100 000 public sector population (Table 3).

Table 3: Public sector RTs, inter-provincial variation in staffing ratios per 100 000 public sector population, 2019

RT category	National average	First RP	Third RP	Sixth RP	Ninth RP
Occupational therapists	2.64	NC 5.88	FS 3.22	MP 2.34	KZN 1.94
Speech therapists & audiologists	1.51	NC 2.99	MP 1.72	LP 1.51	NW 0.86
Physiotherapists	3.10	NC 6.29	FS 3.38	NW 2.98	MP 2.63

Source: PERSAL.²¹

Population: Calculated using the Thembisa model²³ and the StatsSA General Household Survey.¹²

FS = Free State; KZN = KwaZulu-Natal; LP = Limpopo province; MP = Mpumalanga province; NP = Northern Province; NW = North West; RP = ranked province.

The provinces were ranked on the basis of the staffing norms; the Northern Cape ranked first, with the highest staffing ratios in the public sector. It has a small population size and fewer RTs in the private sector than other provinces. KwaZulu-Natal ranked ninth, possibly because of its large population and the presence of a more dominant private sector.¹

Projections for national public sector RTs

Using the historical trends, the number of national public sector disability and rehabilitation therapists was projected up to 2030. Using this scenario, it was assumed that the average growth rate experienced in the three years from 2017 to 2019 would continue to 2030. The results are shown in Table 4.

Table 4: Projected numbers of South African public sector RTs, a historical trend scenario for 2019-2030

RT category	Year												Average annual compound growth
	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	
Occupational therapists (N)	1 279	1 297	1 309	1 320	1 332	1 343	1 355	1 366	1 378	1 389	1 400	1 412	0.90%
Speech therapists & audiologists (N)	730	753	775	796	818	840	861	883	905	926	948	969	2.61%
Physiotherapists (N)	1 504	1 545	1 591	1 636	1 682	1 728	1 774	1 819	1 865	1 911	1 957	2 003	2.64%
Total	3 513	3 595	3 675	3 752	3 832	3 911	3 990	4 068	4 148	4 226	4 305	4 384	2.03%

Source: PERSAL.²¹

Population: Calculated using the Thembisa model²³ and the StatsSA General Household Survey.¹²

In the alternative no-growth scenario, it was assumed that the number of RTs in each category would be constant at 2019 levels to 2030, thus a growth of 0% per annum was predicted over the period 2019-2030.

Target RT ratios

Table 5 shows the equity targets set up to reduce existing inter-provincial inequities, and the international benchmarks used to compare South Africa's RTs.

Table 5: RT target ratios per 100 000 uninsured population to be achieved in South Africa by 2030

RT category	Equity target ratios		International benchmark level
	Sixth RP	Third RP	
Occupational therapists	2.34	3.22	75 ²⁷
Speech therapists & audiologists	1.51	1.72	4 ²⁸
Physiotherapists	2.98	3.38	10 ²⁹

RP = ranked province.

Number of RTs needed to achieve target ratios by 2030

The gap in RTs was estimated for all categories in each of the two growth scenarios, compared with each of the four identified target ratios (Table 6). The numbers denote the number of additional RTs required by 2030 to achieve the equity target ratios (horizontal equity).

Using an historical trends scenario, an additional 743 RTs would be required in total for the three categories to maintain the 2019 ratios in each province. To increase ratios in the last three provinces (sixth RP), an additional 837 RTs

would be required, while achieving the third RP target would require a 1 214 increase. Meeting international benchmarks would require 42 524 RTs.

The number of RTs required was slightly lower under the more optimistic no-growth scenario (as the growth has shown both positive and negative trends over the years). According to this scenario, an additional 425 RTs need to be hired in the public sector to improve inter-provincial equity and achieve the sixth RP and third RP target, where all provinces would have at least 623 and 1 216 RTs respectively.

Table 6: National RT gap in 2030, using two growth scenarios and four target ratios

RT category	Target ratios (per 100 000 uninsured population)		RT gap in 2030 on the basis of future growth scenarios (N)	
			Historical trend scenario	No-growth scenario
Occupational therapists	Using current ratios for each province	Status quo	391	161
	2.34	Sixth RP	449	233
	3.22	Third RP	696	580
	75	International benchmark	37 881	37 981
Speech therapists & audiologists	Using current ratios for each province	Status quo	119	72
	1.52	Sixth RP	145	141
	1.72	Third RP	194	245
	4	International benchmark	1 206	1 384
Physiotherapists	Using current ratios for each province	Status quo	233	192
	2.98	Sixth RP	243	249
	3.38	Third RP	324	391
	10	International benchmark	3 436	3 802

RT category	Target ratios (per 100 000 uninsured population)	RT gap in 2030 on the basis of future growth scenarios (N)	
		Historical trend scenario	No-growth scenario
Total RTs needed	Status quo	743	425
	Sixth RP	837	623
	Third RP	1 214	1 216
	International benchmark	42 523	43 167

RP = ranked province.

Discussion

Variation, inaccuracies, and underreporting of disability data in South Africa and globally remain a major challenge in planning for rehabilitation services. These challenges led to differences in the reported prevalence of disability estimates in South Africa. The quadruple burden of disease in South Africa is associated with a number of impairments, which add to the disability burden.^{17,30,31} The associated major burden of disease impairments includes and is not limited to maternal and child health (birth trauma, cerebral palsy, stunting, developmental delay, mental illness, visual and hearing impairment); HIV and tuberculosis (neurological impairments, dementia, mental illness, tuberculosis of the spine, joint disease, pain and fatigue, antiretroviral side-effects, ototoxic side-effects of tuberculosis medication); trauma and violence (spinal cord injury, traumatic brain injury, amputation, orthopedic complications, mental illness); and non-communicable disease (stroke, diabetic retinopathy, neuropathies, amputation, mental illness, visual loss).³⁰ All these medical conditions contribute significantly to the disability load as they require rehabilitation, and highlight the overwhelming need for more RTs in South Africa.

To address the current shortage of RTs, the following three guiding questions are relevant.

Which RTs will be required to ensure effective coverage of an agreed-upon package of healthcare benefits?

It is clear that there is a need to scale up the core team of RTs as they largely shoulder the responsibility for rehabilitation. This upscaling is especially critical as rehabilitation incorporates other components of health care in practice (prevention, promotion, education, and advocacy). In total, there are around 3 500 RTs registered as OTs, STAs, and PTs in South Africa. The World Report on Disability provides data from four Southern African countries, and indicates that only 26-55% of people receive the medical rehabilitation they need.⁴ South Africa's role here is critical as the country not only provides trained RTs to cater for local needs but provides therapists for some other African countries as well. Furthermore, alignment

between provincial disability prevalence and the human resources needed would be a critical step in determining how much additional training is needed. Alignment means establishing the number of requisite staff needed for the current disability prevalence in each province, and using these data to guide training for new recruits to bridge service gaps.

How can this health workforce be scaled up to progressively expand coverage over time?

When population density is compared with growth in numbers of the three professions (PERSAL headcounts), steady growth can be observed over a period. For example, until 2012, the three professions continued to show positive growth. However, from 2016 onwards, growth in the number of professionals in the three categories started declining in the public sector. Consistent with the literature, this reduced growth in numbers could be attributed to poor recruitment, absorption, and retention of newly graduating healthcare professionals post community service in the public health sector.²⁰ A study conducted by the Academy of Science of South Africa (ASSAf) in 2018,²⁰ emphasised a retention gap of 77.6% for OTs, 81.2% for STAs and 83.1% for PTs. Thus there is a need for equity-based HRH planning to recruit, deploy, and retain right numbers of RTs in the provinces facing critical shortages.

How can South Africa prioritise, deploy, and retain RTs, who help to support universal health coverage and ensure access to care for all?

There is a need to assess inter-provincial disparities in RT density. For instance, provinces with the lowest availability of RTs in the public sector are KwaZulu-Natal (lowest density of OTs), North West (lowest density of STAs), and Mpumalanga (lowest density of PTs) compared with the other six provinces in the country.

Further research needs to be done to determine why rehabilitation professionals are unable or unwilling to work in these provinces, and to establish reasons for the discrepancies between the public and private sectors. To alleviate shortages, the private and public sectors should be integrated, and an assessment needs to be done of the inter-provincial discrepancies in remuneration being offered

to these professionals. If the HRH national average for public sector RTs (per 100 000 public sector population) is compared with other countries, then the figures show that South African ratios are 32 times lower than the international benchmark for OTs, 2.5 times lower for STAs, and 3.4 times lower for PTs.

Conclusion

South Africa has an inadequate supply of RTs to meet the needs of the public health system. There is a need to train greater numbers of RTs, and to reduce existing inter-provincial inequities in number of RTs serving in the public sector. Availability of RTs (in optimum numbers) will play a crucial role in safeguarding and ensuring universal health coverage for the population of South Africa.

Recommendations

A four-pronged strategy is proposed to meet the shortage of RTs. A step-by-step approach has been suggested based on duration (short, medium and long term) and availability of resources, and building overall national training capacity.

In the short term (2-5 years), one way of addressing rehabilitation HRH cost-effectively is to re-open training for profession-specific MLWs in higher education institutions. Such MLWs can be trained as RTs, with basic generic training in a range of disciplines (with skills and knowledge in mobility, communication, mental health, play, learning, work, and most importantly, empowerment), or as profession-specific assistants/technicians providing rehabilitation services under supervision.^{1,32,33} This category of workers would be helpful in reducing the workload, and would enable task-shifting from current therapists providing rehabilitation services.

In the medium term (5-10 years), training, absorption in the public sector, and continuing professional development of community-based rehabilitation workers should be developed and supported in a collaborative partnership across the health, social development, and education sectors. With their specialised skills and experience of working at household and community levels, plus training in basic interdisciplinary rehabilitation services, these workers could work across traditional health and social service boundaries to provide basic rehabilitation in the community as needed.^{32,34} These community-based rehabilitation workers would help in expanding reach and addressing the inequity in access due to geographical/spatial barriers in remote and rural contexts. Couper et al. assert that investment in MLW training is worthwhile as these workers are more likely to be retained in underserved areas, their training is shorter, and they are less dependent

on technology and investigations in their clinical practice.³⁵ Furthermore, those who often face financial and transport barriers and who cannot afford to see a private professional would benefit greatly.

In the long term (10-15 years), policy makers should plan, create posts, and deploy trained professionals (OTs, STAs and PTs) as per the equity-based HRH forecasting exercise undertaken in this study. However, this may have budgetary implications, including planning for training institutions to increase the numbers of trained rehabilitation health workers to respond to the need if necessary.

A fourth strategy would be to build the national training capacity of rehabilitation professionals. This capacity building implies that academic institutions of higher learning offering various disability and rehabilitation courses across various provinces ought to increase intake numbers in order to recruit, enrol and produce more prospective rehabilitation graduates.⁴ There is a compelling need to revise the curriculum, with a sharper focus on interdisciplinary rehabilitation professional education. Such training needs to be context specific to meet the needs of the majority of the population.

Linked to the above, there is a need to plan a coordinated intersectoral collaboration between the health, education, and social development sectors, and to engage these sectors to address the health needs of South Africa's population in a collaborative manner. A recent study⁹ noted that the number of OTs increased at a rate of 71% from 2002 to 2018. Although this growth exceeds that of the population, the density of OTs per 100 000 population continues to be substantially lower than global recommendations. This shortage affirms the urgent need to implement task-shifting to both profession-specific and community-based MLWs in order to meet the growing need for rehabilitation services.

Acknowledgements

The authors would like to acknowledge Dr Gail Andrews from the National Department of Health who commissioned the Ministerial Task Team (MTT) on HRH, and Professor Laetitia Rispel, chair of the MTT on HRH, for leading the 2030 HRH Strategy for South Africa.³⁶ The research work in this chapter is drawn from the discussions and inputs provided during the MTT workstream meetings. The chapter uses the forecasting methodology that emerged during the MTT meetings, although the authors forecasted the need only for three categories of rehabilitation health workers, and made extrapolations up to 2030 based on four equity targets. The authors are solely responsible for the contents of the chapter, including any errors or omissions that may arise from it.

References

1. Ned L, Tiwari R, Buchanan H, Van Niekerk L, Sherry K, Chikte U. Changing demographic trends among South African occupational therapists: 2002 to 2018. *Hum Resour Health*. 2020;18(1):22.
2. Ned L, Cloete L, Mji G. The experiences and challenges faced by rehabilitation community service therapists within the South African Primary Healthcare health system. *Afr J Disabil (Online)*. 2017;6:1-11.
3. South African National Department of Health. Human Resources for Health South Africa: HRH strategy for the health sector: 2012/13-2016/17. Pretoria; NDoH; 2011. URL: https://www.gov.za/sites/default/files/gcis_document/201409/hrhstrategy0.pdf.
4. World Health Organization. World Report on Disability 2011. Geneva: WHO; 2011. URL: https://www.who.int/disabilities/world_report/2011/report.pdf.
5. World Health Organization. Rehabilitation 2030: A Call for Action. Geneva: WHO; 2019. URL: <http://www.who.int/disabilities/care/rehab-2030/en/>.
6. Gupta N, Castillo-Laborde C, Landry MD. Health-related rehabilitation services: assessing the global supply of and need for human resources. *BMC Health Serv Res*. 2011;11(1):276.
7. United Nations. Article 1: Purpose. New York: UN; 2006. URL: <https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities/article-1-purpose.html>.
8. Pillay M, Tiwari R, Kathard H, Chikte U. Sustainable workforce: South African audiologists and speech therapists. *Hum Resour Health*. 2020;18(1):1-13.
9. Ned L, Tiwari R, Hess-April L, Lorenzo T, Chikte U. A situational mapping overview of training programmes for community-based rehabilitation workers in Southern Africa: strategies for strengthening accessible rural rehabilitation practice. *Front Public Health*. 2020;8:696.
10. Mduzana L, Tiwari R, Lieketseng N, Chikte U. Exploring national human resource profile and trends of Prosthetists/Orthotists in South Africa from 2002 to 2018. *Glob Health Action*. 2020;13(1):1792192.
11. Louw QA, Berner K, Tiwari R, et al. Demographic transformation of the physiotherapy profession in South Africa: A retrospective analysis of HPCSA registrations from 1938 to 2018. *J Eval Clin Pract*. 2020.
12. Statistics South Africa. General Household Survey 2018. Pretoria: StatsSA; 2019. URL: http://cs2016.statssa.gov.za/wp-content/uploads/2018/07/CS-2016-Disability-Report_-03-01-232016.pdf.
13. United Nations 2018 flagship report on disability and development: realization of the Sustainable Development Goals by, for and with persons with disabilities. UN Doc. A/73/220. New York: UN; 2018. URL: <https://social.un.org/publications/UN-Flagship-Report-Disability-Final.pdf>.
14. Lehmann U. Mid-level health workers. The state of the evidence on programmes, activities, costs and impact on health outcomes. A literature review. WHO and Global Health Workforce Alliance; 2008. URL: https://www.who.int/workforcealliance/knowledge/resources/mlp_review/en/.
15. Lorenzo T, Motau J, van der Merwe T, Janse van Rensburg E, Cramm JM. Community rehabilitation workers as catalysts for disability: inclusive youth development through service learning. *Dev Pract*. 2015;25(1):19-28.
16. Gamiet S, Rowe M. The role of rehabilitation care workers in South African healthcare: A Q-methodological study. *Afr J Disabil*. 2019;8.
17. South African National Department of Health. Framework and strategy for disability and rehabilitation services in South Africa 2015-2020. Pretoria: NDoH; 2015.
18. Morris LD, Grimmer KA, Twizeyemariya A, Coetzee M, Leibbrandt DC, Louw QA. Health system challenges affecting rehabilitation services in South Africa. *Disabil Rehabil*. 2019:1-7.
19. Rispel LC, Blaauw D, Ditlopo P, White J. Human resources for health and universal health coverage: progress, complexities and contestations. In: Rispel LC, Padarath A, editors. *South African Health Review 2018*. Durban: Health Systems Trust; 2018. p.13-21.
20. Academy of Science of South Africa. Reconceptualising health professions education in South Africa: Consensus study report. Pretoria: ASSAf; 2018. URL: <https://research.assaf.org.za/handle/20.500.11911/95>.
21. Personnel and Salary Information System (PERSAL); 2019. URL: <http://www.vulindlela.gov.za/>.
22. Sharma K, Zodpey SP, Gaidhane A, Quazi SZ. Methodological issues in estimating and forecasting health manpower requirement. *Journal of Public Administration and Policy Research*. 2014;6(2):25.
23. Johnson LF, May MT, Dorrington RE, et al. Estimating the impact of antiretroviral treatment on adult mortality trends in South Africa: A mathematical modelling study. *PLoS Med*. 2017;14(12):e1002468.
24. Yang W, Williams JH, Hogan PF, et al. Projected supply of and demand for oncologists and radiation oncologists through 2025: an aging, better-insured population will result in shortage. *J Oncol Pract*. 2014;10(1):39-45.
25. Smith BD, Haffty BG, Wilson LD, Smith GL, Patel AN, Buchholz TA. The future of radiation oncology in the United States from 2010 to 2020: Will supply keep pace with demand? *J Clin Oncol*. 2010;28(35):5160-65.

26. Brownlee J. A gentle introduction to exponential smoothing for time series forecasting in python. Time Series; 2018. URL: <https://machinelearningmastery.com/exponential-smoothing-for-time-series-forecasting-in-python/>.
27. World Health Organization. The need to scale up rehabilitation. Rehabilitation 2030: A Call for Action. Geneva: WHO; 2017. URL: <https://www.who.int/disabilities/care/NeedToScaleUpRehab.pdf>.
28. American Speech Language Hearing Association. ASHA-Certified Personnel-to-Population Ratios. Rockville: ASHA; 2017. URL: <https://www.asha.org/uploadedFiles/Personnel-to-Population-Ratios-State.pdf>.
29. Balaganessin M. Physiotherapists plead for government support. The Hindu; 15 August 2013. URL: <https://www.thehindu.com/news/cities/Tiruchirapalli/physiotherapists-plead-for-government-support/article5025512.ece>.
30. Sherry K. Disability and rehabilitation: Essential considerations for equitable, accessible and poverty-reducing health care in South Africa. In: Padarath A, King J, English R, editors. South African Health Review 2014. Durban: Health Systems Trust; 2014. p. 89-99.
31. Hanass-Hancock J, Regondi I, Naidoo K. Disability and HIV: What drives the interrelationship between disability and HIV in Eastern and Southern Africa? Afr J Disabil. 2013;2(1):25.
32. Stanmore E, Waterman H. Crossing professional and organizational boundaries: the implementation of generic rehabilitation assistants within three organizations in the northwest of England. Disabil Rehabil. 2007;29(9):751-9.
33. World Health Organization. The education of mid-level rehabilitation workers: recommendations from country experiences. Geneva: WHO; 1992. URL: <https://apps.who.int/iris/handle/10665/61442>.
34. World Health Organization. Increasing access to health workers in remote and rural areas through improved retention: global policy recommendations. Geneva: WHO; 2010. URL: <https://www.who.int/hrh/retention/guidelines/en/>.
35. Couper I, Ray S, Blaauw D, et al. Curriculum and training needs of mid-level health workers in Africa: a situational review from Kenya, Nigeria, South Africa and Uganda. BMC Health Serv Res. 2018;18(1):553.
36. South African National Department of Health. 2030 Human Resources for Health Strategy: Investing in the Health Workforce for Universal Health Coverage. Pretoria: NDoH; 2020. URL: <https://www.spotlightnsp.co.za/wp-content/uploads/2020/08/2030-HRH-strategy-19-3-2020.pdf>.