Erasmus Mundus Joint Master's Degree

Global Development Policy (GLODEP)

MASTER THESIS

The risk of malnutrition among children born to HIV-infected women: Evidence from Tanzania

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GLODEP class of 2024

Declaration

I, Tabea Maria Lucia Gerd-Witte declare that this master thesis with the title *"The risk of malnutrition among children born to HIV-infected women: Evidence from Tanzania"* is my own work and I am the sole author of this thesis. It was written as a partial fulfilment of the requirements to receive an Erasmus Mundus Joint Master's Degree in Global Development Policy. All external sources used in this paper are referenced in this thesis.

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Akademický rok: 2023/2024

ZADÁNÍ DIPLOMOVÉ PRÁCE

(projektu, uměleckého díla, uměleckého výkonu)

Jméno a příjmení:	**Tabea Maria Lucia GERD-WITTE**
Osobní číslo:	**R220478**
Studijní program:	**N0588A330004 Global Development Policy**
Téma práce:	**The risk of malnutrition among children born to HIV-infected women: Evidence from Tanzania**
Zadávající katedra:	**Katedra rozvojových a environmentálních studií**

Zásady pro vypracování

The effect of maternal HIV infections on child malnutrition, birthweight, as well as growth indicators, has been widely studied in the Sub-Saharan context. However, most of these studies do not include Tanzania (e.g., Magadi (2011a, 2011b); Muhangi (2023)) and/or are restricted to child malnutrition in the first two years of life (e.g., McDonald et al. (2012)). Using data from the 2022 Demographic and Health Survey, this thesis focuses on the risk of malnutrition among children born to HIV-infected women in Tanzania. Regression analysis will be carried out to estimate the relationship between maternal HIV infections and child malnutrition in children aged five and younger.

Previous studies on the mechanism of how maternal HIV infections affect child malnutrition are inconclusive. This study will pay special attention to the income channel: HIV-positive individuals are expected to work less due to health restrictions. Even if treated correctly, high prices for antiretroviral drugs (ARTs) restrict the household budget and thus the budget available for food. Tanzania implemented free HIV testing as well as free ARTs in 2004. The presence of a significant effect of maternal HIV infections on child malnutrition would thus indicate that there are other mechanisms apart from the income channel.

Rozsah pracovní zprávy:	**10-15 000 words**
Rozsah grafických prací:	**as needed**
Forma zpracování diplomové práce:	**tištěná/elektronická**
Jazyk zpracování:	**Angličtina**

Seznam doporučené literatury:

Including but not limited to:

- Chatterjee, A., Bosch, R. J., Hunter, D. J., Fataki, M. R., Msamanga, G. I., & Fawzi, W. W. (2007). Maternal disease stage and child undernutrition in relation to mortality among children born to HIV-infected women in Tanzania. *JAIDS Journal of Acquired Immune Deficiency Syndromes*, *46*(5), 599-606.
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Datum zadání diplomové práce: **9. ledna 2024**
Termín odevzdání diplomové práce: **31. května 2024**

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vedoucí katedry

V Olomouci dne 15. ledna 2023

Acknowledgements

First of all, I want to thank Prof. Maria Anna Leone from the University of Pavia for supervising my thesis. Her support, feedbacks and insights have been immensely helpful in the whole process of writing this thesis.

Additionally, I am deeply grateful to everyone at the Soma Kwa Furaha Initiative, especially Clara and Micky, for allowing me to spend three months at their NGO. Without them, I would have never learnt as much about Tanzanian culture, health and educational services.

Also, I want to thank everyone in the GLODEP program. Studying in an international and diverse environment allowed me to learn and grow personally every single day. Special thanks go to my fellow classmates for supporting me throughout the GLODEP journey and making this experience unforgettable.

Lastly, I want to give special thanks to my family for encouraging and supporting me unconditionally throughout my academic journey.

Abstract

HIV/ AIDS as well as child malnutrition remain major public health challenges in Tanzania. This paper investigates whether Tanzanian HIV exposed children under the age of five tend to be at a higher risk of being undernourished than unexposed children. Proxying child HIV exposure status by maternal ART intake, OLS regression analysis is carried out to determine the association between HIV exposure and child malnutrition while controlling for child, maternal and socioeconomic factors. A simple mean test reveals that HIV exposed children tend to be at a higher risk of being stunted, while the risk of wasting is lower for this group of children. There is no evidence of a significant difference in the risk of being underweight. These observations also hold in a bivariate regression analysis and once controlling for the socioeconomic environment as well as other possible confounding factors affecting child undernutrition. In fact, the effects of HIV exposure are stronger once controlling for these variables. The socioeconomic environment is only found to have a significant effect on the risk of stunting with children from wealthier families tending to be at a lower risk of being stunted.

Keywords: HIV exposed children, child malnutrition, child undernutrition, HIV/ AIDS, Tanzania

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1 Internship stay at Soma Kwa Furaha Initiavtive, Mwanza, Tanzania

This thesis was written as part of a three months internship stay at the Soma Kwa Furaha Initiative, Tanzania.

The Soma Kwa Furaha Initiative (SKFI) is a NGO based in Mwanza, Tanzania. It was founded in 2021 and its main mission is inclusive development through the three pillars of health, education and community empowerment (SKFI, 2024). The organization is currently implementing several projects, including workshops for female empowerment, supporting disabled children in accessing education and health services as well as support groups for parents of disabled children.

Basis of my internship was the work at a school for disabled children, often from socio-economically disadvantaged families. Our everyday work was concerned with helping these children accessing medical services as nutritional screening, HIV testing as well as tests for other infectious diseases. During home visits of the children's place of living, I gained knowledge on life with a disabled child in Tanzania where disability is still connected to a high degree of stigmatization.

I want to thank everyone for the enriching discussions about the Tanzanian health system, structural discrimination and stigmatisation and how to address these issues on a small scale. Special thanks go to Mama P. for opening up to me and telling me about secretly living with an HIV infection. Her personal story about stigmatisation and obstacles to the uptake of HIV treatment have motivated me immensely in diving deeper into the issue of HIV/ AIDS as well as HIV exposure in Tanzania.

2 Introduction

Despite international efforts to end all kinds of child malnutrition by 2030 (SDG Target 2.2), child undernutrition in Tanzania remains on a high level. In 2022, 30.6% of children under the age of five years were estimated to be stunted, while 3.3% of all children below five years were estimated to be moderately wasted (UNICEF et al., 2023). Besides the adverse effects of malnutrition on immediate individual health outcomes, malnutrition during early childhood impairs cognitive and physical development and thus also human capital as well as long-term economic productivity on a national scale (Arpadi et al., 2009). Emphasis should thus be placed on identifying possible risk factors of child malnutrition in order to fight its root causes. One vulnerable group of children that might be at higher risk of malnutrition are those born to HIV positive mothers that themselves remain negative (*HIV exposed children*).

This thesis aims to provide evidence on the relationship between HIV exposure and child undernutrition in Tanzanian HIV exposed children under the age of five and on how the socioeconomic environment affects this relationship. Providing evidence based on recent nationally representative data will help inform policy interventions targeted at children adversely impacted by HIV exposure and/ or malnutrition.

Tanzania is still suffering under a high burden of HIV, even though there has been tremendous progress in eradicating HIV/ AIDS in the past two decades,. UNAIDS (2024) estimates the HIV prevalence among adults of reproductive age to be 4.3% in 2023, translating into 1.7 million people of reproductive age living with HIV. This has not only implications in terms of individual health and human capital but is also destructive for economic productivity and growth. As in most countries, the use of antiretroviral therapy (ART) to prevent mother-to-child transmissions has become the dominant strategy in preventing paediatric HIV infection. As access and availability of ARTs have been scaled up in the past two decades (UNAIDS, 2023), the number of HIV exposed children in Tanzania but also worldwide is steadily rising. Policies targeting the nutritional status of HIV exposed children are thus of major importance for public health interventions, especially in countries with high

HIV prevalence.

Numerous studies have been carried out on malnutrition in HIV seropositive (henceforth HIV positive) individuals, both during childhood and adolescence. Without proper treatment, the HIV infection causes the body to have a higher energy need while at the same time limiting the capacity to absorb nutrients and decreasing appetite. As a consequence, HIV positive individuals are at a higher risk of malnutrition compared to HIV seronegative (henceforth HIV negative) individuals (Koethe & Heimburger, 2010). In fact, half of all HIV positive children show poor growth patterns, especially in terms of stunting (Arpadi, 2000).

Malnutrition in HIV-exposed children is less well-studied, especially in the Tanzanian context. Until now, there has only been one study focusing on malnutrition in HIV exposed children. Using the WHO Child Growth Standards, McDonald et al. (2012) find that HIV exposed children are at a lower risk of being stunted, wasted and underweight compared to HIV-infected children throughout the first two years of life. However, the study only estimates predictors of malnutrition in the Tanzanian setting and does not provide any comparison with a control group of unexposed children. There is, at this date, no longitudinal study on undernutrition in HIV exposed (uninfected) children compared with HIV unexposed children in Tanzania that provides a broader picture on the national level and allows to analyze the effect of the socioeconomic environment. The only population-based study in the Sub-Saharan context of HIV exposure and child malnutrition, Magadi (2011-a), focuses on children born to HIV positive mothers but does not differentiate between HIV negative and HIV positive children. Even though she finds Sub-Saharan HIV exposed children to be at a significantly higher risk of stunting, wasting and underweight compared to unexposed children once controlling for the socioeconomic environment, estimates might be biased due to the poorer growth patterns in HIV positive children.

Secondary analysis of different waves of the Demographic and Health Survey (DHS) from Tanzania allows for a population-based analysis of the relationship between HIV exposure and malnutrition in children under the age of five. This thesis provides a descriptive analysis of trends and patterns in the HIV/ AIDS epidemic in Tanzania as well as on anthropometric indicators of undernutrition in Tanzanian children under the age of five (stunting, wasting, underweight). In a second step, malnutrition in HIV exposed children is investigated based on DHS 2022 data. HIV status of children is proxied by maternal ART intake as data on child HIV status is not provided by the DHS. Firstly, simple mean tests as well as chi squared tests are carried out to detect significant differences in the mean z-scores and levels of stunting, wasting and underweight in HIV exposed and unexposed children. This is then followed by an OLS regression, investigating if HIV exposed children are at a higher risk of being stunted, wasted or underweight in the Tanzanian setting. Besides child and maternal characteristics, DHS data also allows to control for the socioeconomic environment and analyze how it affects the relationship between HIV exposure and malnutrition found in the simple mean tests and a bivariate OLS regression analysis. The objective of this paper is thus to answer the following questions:

1. Do HIV-exposed Tanzanian children under the age of five have, on average, a poorer nutritional status than HIV-unexposed children?

2. How does the socioeconomic environment of HIV-exposed children under the age of five in Tanzania affect the relationship between HIV-exposure and undernutrition?

The descriptive analysis reveals that both HIV/ AIDS as well as child malnutrition remain as public health challenges, with child malnutrition being the more pressing issue. HIV prevalence was estimated to be 3.51% in 2022, with rates tending to be higher for older females of reproductive age. With almost all HIV positive individuals (96.35%) being put on ART and an HIV incidence in the country as low as 0.56%, the country can expect decreasing HIV prevalence in the future. However, HIV testing remains on a concerningly low level of 73.18% with testing rates being significantly higher for females. Child undernutrition remains a public health threat as every third child in Tanzania under the age of five is estimated to suffer from at least one form of undernutrition. Stunting, wasting and underweight prevalence are estimated to be 29.66%, 3.22% and 11.63% respectively. Carrying out simple mean tests, the study finds that stunting z-scores of HIV exposed children are significantly lower than of HIV unexposed children. Wasting z-scores of HIV exposed children on the other hand are significantly higher in HIV exposed children while no significant difference in underweight z-scores could be found. The prevalence of stunting, wasting, and underweight is not found to differ significantly between the two groups. OLS regression analysis confirms these findings, with the effect of HIV exposure on stunting and wasting appearing to be stronger once controlling for child, maternal and socioeconomic characteristics. HIV exposure is found to have a significant, negative effect on stunting z-scores while the socioeconomic environment is found to be highly significant with children from wealthier households tending to be at a lower risk of stunting. In terms of wasting and underweight, the socioeconomic environment is not found to have a significant effect and the results found in the mean comparison test are also found once controlling for the socioeconomic environment.

This thesis aims to add to the existing knowledge and academic debate on health outcomes in HIV exposed children. Several studies have been concerned with the effects of HIV exposure on mortality, morbidity and growth outcomes in the Sub-Saharan settings. For high income settings, most studies show no evidence that HIV exposure adversely affects growth patterns ((Ross et al., 1995), (The European Collaborative Study, 2003), (Pollack et al., 1996)), some even find over average growth in HIV exposed children (Jacobson et al., 2017). In low-income settings, results are more heterogeneous and differ from one study to another. Most studies show a negative association between HIV exposure and growth indicators (e.g., (Jumare et al., 2019), (Arpadi et al., 2009), (Rosala-Hallas, Bartlett, Filteau, et al., 2017)), while others only find it to differ in specific periods (e.g., (Mabaya et al., 2021), (Omoni et al., 2017)). Several other studies do not find significant differences in growth failure when comparing HIV exposed children to HIV unexposed children (e.g., (Muhangi et al., 2013), (McHenry et al., 2019)).

Within the group of literature concerned with growth patterns in HIV exposed children, only few focus on growth outcomes as an indicator of nutritional status. Even within the group of studies focussed on malnutrition, two types of studies have emerged. On the one hand, several studies are based on secondary analysis of RCT data and provide thus only evidence on malnutrition levels in HIV exposed children compared to HIV unexposed children with similar characteristics at baseline of the study (e.g., (Pollack et al., 1996), (Mabaya et al., 2021)). Due to the nature of the RCTs, many study samples are regionally restricted (e.g., (McDonald et al., 2012), (Arpadi et al., 2009), (Muhangi et al., 2013)) and thus not always generalizable to the national level. On the other hand, there is an emerging strain of literature hypothesising that differences in growth patterns might not only be due to HIV exposure but rather due to other factors as differing socioeconomic environments or biological reasons. This thesis aims to add to the latter strain of literature by providing evidence on how the socioeconomic environment affects the relationship between HIV exposure and child undernutrition. Once controlling for possible confounding factors, several studies do not find a significant effect of HIV exposure but of the socioeconomic environment(e.g., (KÃ¶nig Walles et al., 2017), (König Walles, Balcha, Winqvist, & Björkman, 2017), (The European Collaborative Study, 2003)) or breastfeeding more (Patel et al., 2010). However, there is no consensus on this topic in literature and the different channels still needs to be explored further. This paper aims to add some evidence on the socioeconomic channel in the Tanzanian context.

The remainder of this paper is organized as follows: Section 3 provides an overview on the conceptual framework of this paper by summarizing potential channels on how HIV exposure could affect a child's nutritional status. This is followed by a descriptive study of the state of the HIV/ AIDS epidemic in adults of reproductive age as well as the nutritional status of all children under the age of five in Tanzania (Section 4). Section 5 will then focus on malnutrition in HIV exposed children by carrying out regression analysis, controlling for the socioeconomic environment.

3 Conceptual framework

As described in Section 2, there is no consensus on how HIV exposure might affect a child's nutritional status. However, the potential channels outlined in other articles can be classified into biological as well as socioeconomic mechanisms. The following section will provide an overview over the channels discussed in the academic literature.

In utero reasons: Postnatal growth might be influenced by the child's in utero environment. Fetal malnutrition due to in utero HIV exposure as well as maternal inflammation during pregnancy might not only affect fetal growth but also have adverse effects on a child's growth part after birth ((Muhangi et al., 2013), (Omoni et al., 2017)). In fact, HIV exposed children tend to have a smaller birth weight and birth size than HIV unexposed children regardless of the child's HIV status ((Filteau, 2009), (Makasa et al., 2007)). Additionally, HIV exposed children could be more vulnerable to diseases as the in utero environment might have adverse effects on their immune function (Arpadi et al., 2009).

Breastfeeding: Due to the low availability and high prices of infant formula in many low-income countries, HIV infected women are recommended to exclusively breastfeed their children for 12 months only (WHO, 2015). An earlier cessation of breastfeeding compared to uninfected women might have adverse effects on the development of the child's immune system (Filteau, 2009). However, Filteau (2009) also finds that breastfeeding cannot be the sole transfer mechanism as growth differences could also be observed in HIV exposed children breastfed for a longer period of time.

Higher infection risk: Due to the reduced immune capacity of their HIV infected mothers and sometimes other household members, HIV exposed children are at a higher risk of contracting infectious diseases and exposure to other pathogens, especially tuberculosis ((Filteau et al., 2023), (König Walles et al., 2017)). Additionally, HIV exposed children might show some immune abnormalities caused by being HIV exposed in utero, especially in terms of t-cells, reducing their immune capacity (Filteau, 2009).

Socioeconomic reasons: Another possible channel are impoverishing effects that follow a household member's HIV infection. A reduction in economic and/ or agricultural productivity due to diseases associated with the HIV infection leads to a higher risk of household food insecurity and thus also food insufficiency and undernutrition ((Magadi, 2011-a), (Filteau et al., 2023)). Moreover, HIV positive individuals might require additional care from other family members, reducing the labor capacity even more (Dasgupta et al., 2016). As mothers to HIV exposed children are at a higher risk of being malnourished and thus possibly not able to fulfill their economic potential due to their HIV infection, the risk of household food insecurity increases additionally (Muhangi et al., 2013). Furthermore, in case of a high cost for HIV services, increased healthcare expenditures might strain the household even more (Dasgupta, Bhattacherjee, & Das, 2016). Dasgupta et al. (2016) found only approximately half of all Indian households with at least one HIV infected member to be food secure and a negative, significant association between food security and HIV infection. Social factors as stigmatization (Muhangi et al., 2013) as well as strained health services in communities adversely affected by HIV/ AIDS (Magadi, 2011-a) may disadvantage HIV exposed children further. Existing studies do not show a conclusive picture regarding the socioeconomic environment and undernutrition in HIV exposed children. Magadi (2011-a) finds socioeconomic factors to matter significantly for child undernutrition, but finds that there are other channels apart from socioeconomic factors. However, other studies do not find factors associated with the socioeconomic environment to have a significant effect on nutritional status. Mabaya et al. (2021) as well as Omoni et al. (2017) did not find educational attainment and maternal income to have a significant effect on malnutrition, while Arpadi et al. (2009) does not find evidence of food insecurity and employment status to have a significant impact on underweight.

Parenting: According to Arpadi et al. (2009) and Muhangi et al. (2013), especially advanced stages of HIV might compromise care-giving capacity. The HIV infection might decrease physical and mental capacity and thus also the support the mother can offer to the child in the early development stages of the child's life. The use of ARTs, however, should lead to an improval of parent's care capacities (Filteau, 2009).

4 Descriptive study: HIV/ AIDS and child malnutrition in Tanzania

As described in the introduction, Tanzania is hit by a double burden of high child malnutrition rates as well as the ongoing HIV/ AIDS epidemic. The following chapter will provide a descriptive study on the state of the HIV/ AIDS epidemic as well as undernutrition in Tanzania. More specifically, focus will be paid to HIV testing, HIV prevalence, and knowledge of mother-to-child transmissions in the population of reproductive age. Furthermore, different indicators of undernutrition in all Tanzanian children under the age of five will be explored.

4.1 Data

The descriptive study is based on Tanzanian DHS data collected between 1992 and 2022. The DHS is a household-based study that provides a comprehensive dataset on health, socioeconomic and population-related data that is representative on both national, regional level as well as according to urban and rural residence (The DHS Program, n.d.). As sampling methods and variables provided for the purpose of statistical analysis are consistent over time, the DHS allows to compare different survey cohorts in order to detect time trends and cross-country as well as within-country differences (ICF, 2018). However, not all questions are asked during each survey and information is thus not always provided on each variable for each cohort. The cohorts of 1991-1992, 1996, 1999, 2004-2005, 2010, 2015-2016 and 2022 provide information on the nutritional status of children, while the cohorts of 1996, 1999, 2003-2004, 2004-2005, 2007-2008, 2010, 2011-2012, 2015-2016 and 2022 contain HIV/ AIDS related data. Data on HIV test results is available for the years 2004, 2008, 2012, 2022. An overview if the different DHS cohorts can be found in Table 1. For waves of data, where data was collected in two different years, the cohort will be refered to with the second year

Cohort	**1991-1992**	**1996**	**1999**	**2003-2004**	**2004-2005**
Type of survey	DHS	DHS	DHS	AIS	DHS
Fieldwork	10/91 - 03/92	07/96 - 11/96	09/99 - 11/99	12/03 - 03/04	10/04 - 02/05
Household sample size	8,327	7,969	3,615	6,499	9.735
HIV testing	No	Yes[a,b]	Yes[a,b]	Yes	Yes[b]
HIV prevalence	No	No	No	Yes	No
ART coverage	No	No	No	No	No
Knowledge vertical transmission	No	Yes	Yes	Yes	Yes
Stunting	Yes	Yes	Yes	No	Yes
Wasting	Yes	Yes	Yes	No	Yes
Underweight	Yes	Yes	Yes	No	Yes
Cohort	**2007-2008**	**2010**	**2011-2012**	**2015-2016**	**2022**
Type of survey	AIS	DHS	AIS	DHS	DHS
Fieldwork	10/07 - 02/08	12/09 - 05/10	12/11 - 05/12	08/15 - 02/16	03/22 - 07/22
Household sample size	8,479	9,623	10,040	12,563	15,705
HIV testing	Yes	Yes	Yes	No	Yes[a]
HIV prevalence	Yes	No	Yes	No	Yes
ART coverage	No	No	No	No	Yes
Knowledge vertical transmission	Yes	Yes	Yes	No	No
Stunting	No	Yes	No	Yes	No
Wasting	No	Yes	No	Yes	No
Underweight	No	Yes	No	Yes	No

a: no data on last HIV test; b: no data on testing during pregnancy;

Table 1: DHS Cohorts for Tanzania, 1992-2022

AIDS/ HIV	**Undernutrition**
Gender (*male/ female*)	Gender (*male/ female*)
Age group in completed years (*15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49*)	Age group in completed years (*0, 1, 2 , 3 , 4*)
Residence (*urban/ rural*)	Residence (*urban/ rural*)
Region	Region

Table 2: Groups for the descriptive analysis

of data collection (i.e., 1992 for the cohort of 1991-1992).

Besides analyzing the overall status and time trends for the whole country, the descriptive study will be carried out for the groups listed in Table 2: gender, age group, residence, and where applicable also according to region. Regional analysis is based on the regions displayed in Figure 1.

4.2 HIV/ AIDS

Following the WHO (n.d.-a) definition, the *"Human immunodeficiency virus (HIV) is an infection that attacks the body's immune system. Acquired immunodeficiency syndrome (AIDS) is the most advanced stage of the disease. [...] HIV is spread from the body fluids of an in-*

Figure 1: Tanzanian regions

fected person, including blood, breast milk, semen and vaginal fluids. It is not spread by kisses, hugs or sharing food. It can also spread from a mother to her baby".

Even though HIV infections cannot be cured, they can be treated with antiretroviral treatment (ART). Currently, there are seven classes of ART drugs on the market that are prescribed according to the disease advancement, comorbidities and/ or individual needs (US National Institute of Health, 2021). ARTs decrease the viral load in the blood and disease progression in HIV positive individuals can be prevented (WHO, n.d.-a). Complying with the intake of the daily ART regimen, the viral load can be suppressed to undetectable levels within 3-6 months of starting the treatment (US National Institute of Health, 2021) and the life expenctancy of the HIV-suppressed individual is the same as in HIV negative individuals (UNAIDS, n.d.-a). A recent systematic review of studies on sexual HIV transmission conducted by Broyles, Luo, Boeras, Vojnov, et al. (2023) found the transmission rate between couples to be zero in case of compliance with the ART intake. These drugs are therefore also used as pre- and post-exposure prophylaxis for uninfected people intending to have sexual contact with HIV infected individuals or any other form of possible exposure (WHO, n.d.-a). Additionally, ARTs are administered to prevent mother-to-child transmissions (vertical transmissions) during pregnancy, delivery and breastfeeding period. Lyatuu et al. (2023)'s study, the largest one in the Sub-Saharan region so far, finds a vertical transmission rate of 1.4% from Tanzanian HIV infected pregnant women taking ARTs to their children until 18 months post-partum. This is a substantial decrease from vertical transmission rates up to 45% without ART intake (Lyatuu et al., 2023). The current dominant strategy to eliminate paediatric HIV infections through mother-to-child transmission is *Option B+*, recommending lifelong initiation of ARTs for all women that are pregnant and/ or breastfeeding regardless of disease advancement. This does not only prevent vertical transmissions but also increases maternal health outcomes (WHO, 2015). Access to ARTs differs by country, but the WHO (n.d.-b) estimates that 76% of all HIV positive individuals worldwide have access to antiretroviral therapy, a threefold in the proportion accessing ARTs since

2010. The number is even higher for pregnant women, with 82% of all globally infected and pregnant women receiving ARTs.

Since 2004, Tanzania provides universally free HIV services including testing and ART provision, also covering ARTs as pre- and post-exposure prophylaxis, during pregnancy, delivery and breastfeeding period (Mnzava et al., 2018). Until 2008, HIV service provision was centralized to urban health facilities only, but was later decentralized to all levels of health facilities. This also includes increasing the number of ART pickup points as well as the stack of available ART medication (Mnzava, Mmari, Berruti, et al., 2018). By 2015, ARTs were dispensed in 85% of all Tanzanian hospitals, 71% of other health centers and 90% of these had enough stock to initiate same-day start of treatment for newly diagnosed individuals (MOHSW et al., 2015). The Tanzanian government adopted Multi-Months Dispensing (MMD) of ARTs, meaning that ARTs are dispensed for several months during one health facility visit. In 2022, 63% of all HIV-positive individuals received their treatment for 6 months (6 MMD), while 19% followed 3-5 MMD and the remaining 18% followed less than 3 MMD (ICAP, 2023).

In order to coordinate the national efforts to fight the HIV epidemic, the Tanzanian government established the Tanzania Commission for AIDS (TACAIDS) in 2001 which is also responsible for monitoring and evaluating the policies (TACAIDS, NBS, & Macro, 2005). Tanzania has implemented several national policies and plans with the objective of fighting the HIV/ AIDS epidemic by 2030. In addition to several plans targeted at the health sector only, the country has currently adopted the Fifth National Multisectoral Strategic Framework for HIV and AIDS (NMSF V), containing guidelines for several sectors for the years 2021/2022 to 2025/ 2026 (United Republic of Tanzania, 2022). However, insufficient health infrastructure, financing gaps as well as stigmatization among others, pose challenges to achieving the goals (USAID, 2023). For example, the majority of the NMSF V is financed by foreign partners, and domestic resources only account for 10% of the financing (United Republic of Tanzania, 2022).

On the international level, Tanzania has committed to the $95-95-95$ strategy of the United Nations, a milestone towards SDG Target 3.3 of ending the HIV epidemic by 2030 (United Republic of Tanzania, 2022). According to UNAIDS (n.d.-b), the targets to be reached by 2025 are as follows:

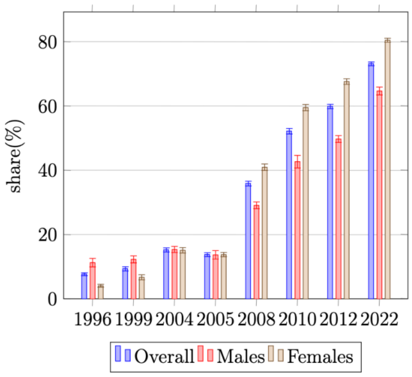
- The first 95: *"At least 95% of people living with HIV know their status"* (Indicator for HIV testing)
- The second 95: *"At least 95% of people who know their HIV status are on treatment"* (Indicator for HIV treatment)
- The third 95: *"At least 95% of people on treatment have a suppressed viral load"* (Indicator for viral suppression)

The remainder of this chapter will provide an overview over HIV testing, prevalence and incidence, ART knowledge as well as knowledge about vertical transmissions in Tanzania.

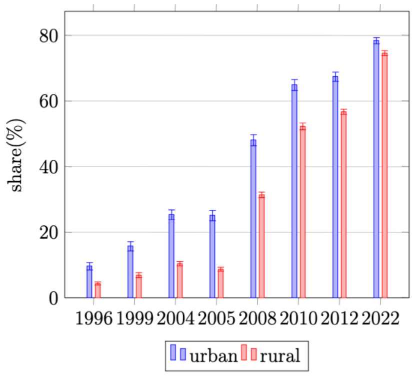
4.2.1 HIV test coverage

HIV testing in males and females of reproductive age (15-49 years) has been increasing over the years, especially since 2005, but remains on a low level. In 2022, 73.18% of all individuals of reproductive age had ever been tested for HIV as can be seen in Figure 2a. An acceleration in testing rates in the past two decades can also be observed for both genders. During the 1990s, more males were tested than females with the male testing rate in 1996 (11.34%) being almost three times as high as the female one (4.15%). However, after testing rates converged to a similar level in 2004 and 2005, female testing increased on a larger scale than for males and was significantly higher for all cohorts after 2005. The newest 2022 estimates reveal a testing rate of 80.51% for females while the male equivalent was at only 64.71%.

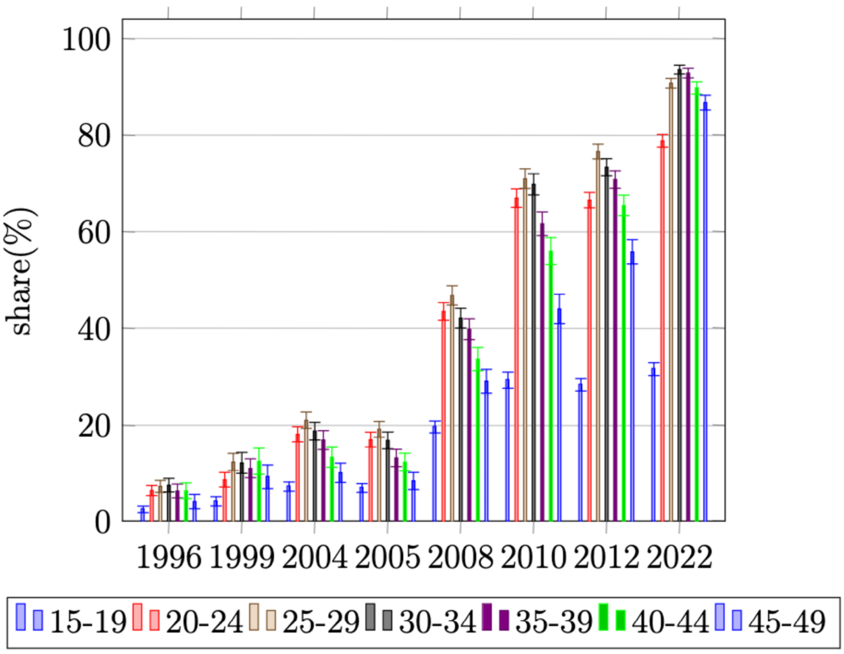
HIV test rates vary by age group but have increased progressively for all age categories (Figure 2c). It is mainly individuals aged between 20 and 44 that have the highest testing rates, while individuals aged 15-19 show the lowest HIV test rates across all groups at all



(a) Gender



(b) Residence



(c) Age

Figure 2: HIV testing according to gender, residence, age, 1996-2022

times. Since 2008, testing rates have been significantly lower for this age group compared to all other groups with the gap to the other groups appearing to diverge over time. In 2022, only 31.60% of all individuals aged 15-19 answered that they had ever been HIV tested. This is 2.5 times less the testing rate in 20-24 year olds, the age group with the second lowest testing rate in 2022 (78.88%). In the group with the highest testing rate in 2022, 30-34 years, it was almost 3 times as many individuals (93.64%) that had ever been tested. Especially the age group of 45-49 year olds caught up in testing rates in the last two decades.

HIV testing coverage is significantly higher in urban than in rural settlements for all times, but has converged over time especially since 2008 (Figure 2b). Since 2005, testing levels have been increasing drastically and rose to 78.44% for urban households and 74.66% for rural households in 2022. This might be due to the fact that free HIV services were only provided in urban health centers until 2008, incentivizing more urban people to get tested for HIV (Mnzava et al., 2018).

Figure 3 shows that there are spatial differences in HIV test coverage. Test coverage tends to be higher in regions in the south of the country, while regions in the center tend to have lower testing rates. In 2022, 87.21% of all adults of reproductive age living in Njombe answered to have ever been tested for HIV, while the share was 85.19% for Ruvuma and 85.12% for Iringa. The island of Pemba is the region with the lowest HIV test coverage, where only 64.71% of adults of reproductive age answered to have ever been tested for HIV.

Not only did the share of individuals ever been tested for HIV increase since 1996, also the share of individuals that actually received the result of the test increased progressively. While 86.06% received their result in 2004, this number could be monotonously increased to 98.90% in 2022. This trend does not vary greatly by gender, age group or residence.

For the years 2004 to 2010, the DHS provides data on when the last HIV test was taken. In all years, the majority of individuals that have ever taken an HIV test, reported that the last HIV test they took was within the last 12 months (Figure 4). From 2004 to 2008, the share of individuals that had ever been tested for HIV and had their last HIV test more

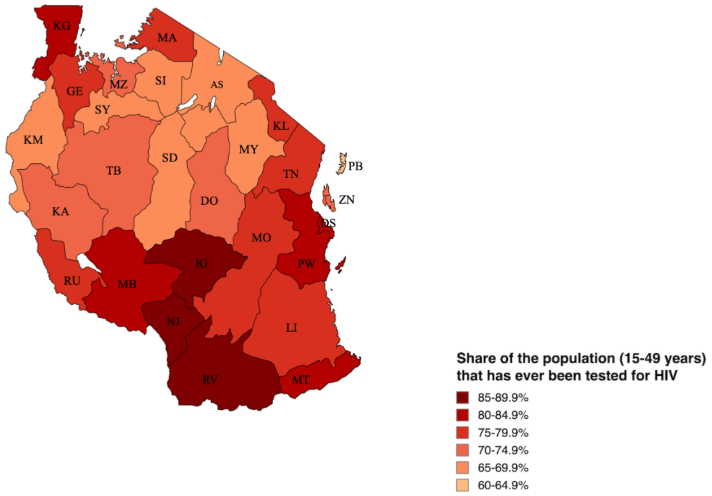


Figure 3: Share of the population that has ever been tested for HIV, 2022

than two years ago was decreasing. 2010 data shows, that the share of people having taken their last HIV test within the last 12 months decreased compared to 2008 levels. Further analysis reveals that it was less females that answered to have taken an HIV test during the past year in the years 2008 and 2010. While it was 71.54% in 2008 and 62.82% in 2010 for males, the share of women was 64.23% and 53.20% for females. Unfortunately there is no data after 2010 to follow the trend during the past decade.

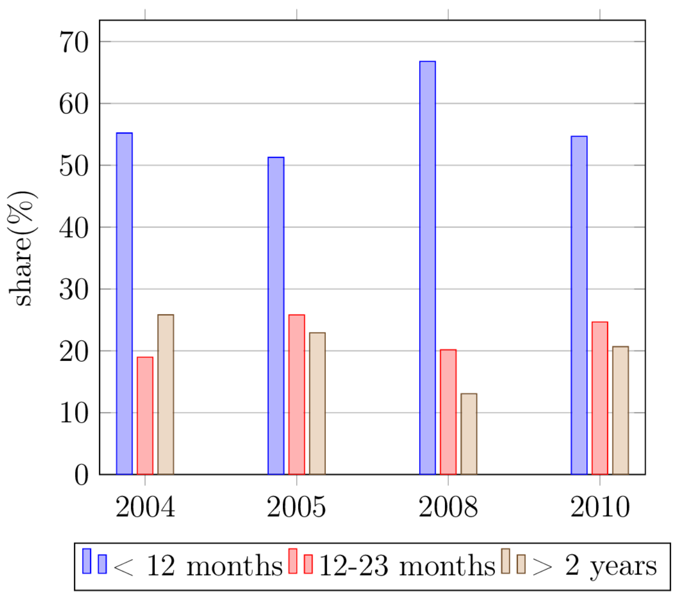
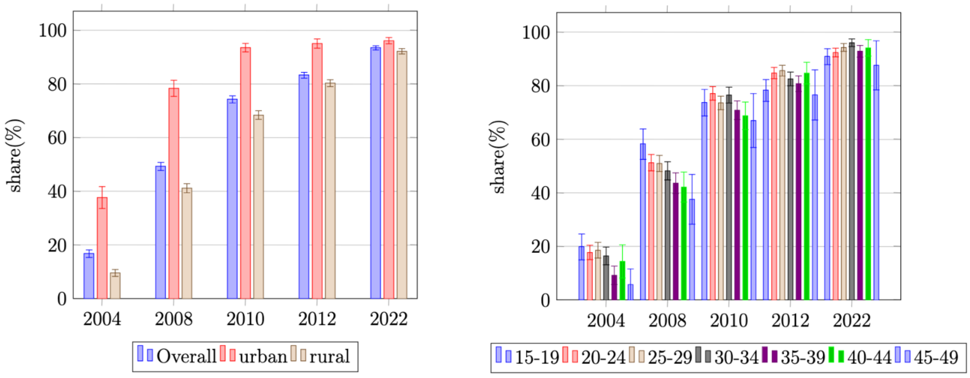


Figure 4: Time since the last HIV test, 2004-2010

As part of their National Multisectoral Strategic Frameworks for HIV and AIDS, the Tanzanian government has promoted HIV testing of women during their pregnancy (United Republic of Tanzania, 2022). Women are tested as part as their first antenatal care visit and HIV exposed children are monitored in monthly visits throughout their first two years of life. During this time, the mothers are provided with ART refills and information on vertical transmissions due to breastfeeding (Lyatuu et al., 2023). Consequently, the share of pregnant women being tested during one of their prenatal checkups has been constantly rising since 2004 (Figure 5a). This could also explain the significantly lower HIV testing rates in Tanzanian teenagers shown in Figure 2c. Starting at a level of 16.80% in 2004, testing rates were at 83.33% in 2012 and could even be raised to 93.51% in 2022. However, testing rates during pregnancy were and are still significantly higher in urban areas than in rural ones. In 2004, only 9.61% of women living in rural areas were tested for HIV during their pregnancy, while it was 3.9 times more (37.73%) for pregnant women in urban areas. Testing rates in rural areas have caught up ever since and reached a similar level in 2022 (96.19% for urban and 92.24% for rural households) even though the difference still remains significant.



(a) Residence

(b) Age

Figure 5: HIV testing as part of antenatal visits according to residence and age, 2004-2022

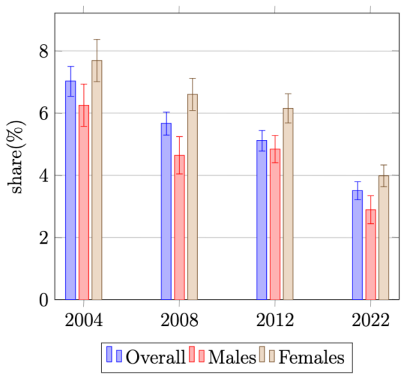
HIV testing rates during pregnancy ranged between 90% and 96% in 2022 for all age groups of reproductive age (Figure 5b). Testing rates have risen monotonously for all age groups between 2004 and 2022, with most progress achieved between 2004 and 2010. Especially in 2004 and 2008, testing rates tended to be higher the younger the females were during their pregnancy. However, this trend is not observable anymore and differences are not significant. In the past decade, HIV testing rates tended to be highest for pregnant women aged 20-44. Similar to regular HIV tests, 98.76% of all pregnant women taking an HIV test as part of an antenatal visit received their test results in 2022. This is a tremendous increase from 78.49% in 2004. This trend does not vary by age group or residence.

4.2.2 HIV prevalence

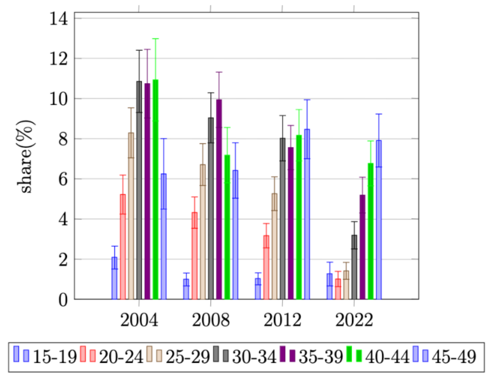
Since 2004, the DHS provides information on the HIV status of eligible individuals, covering persons aged 15-49 years in selected households. HIV-positivity and negativity are determined by blood tests carried out in external laboratories (The DHS Program, n.d.). Even though information on the HIV status is provided, no information is available on the viral load or if an individual is considered to be in an advanced stage of the disease.

Overall, HIV prevalence has decreased between 2004 and 2022 for both males and females of reproductive age, consequently also for the whole population of this age group (Figure 6a). While 7.03% of all individuals of reproductive age were estimated to be HIV-positive in 2004, this number more than halved to 3.51% in 2022. HIV rates remain significantly higher for females than for males, with the gap appearing to divide with time. Male HIV-levels dropped by 54% during this period from 6.26% to 2.9%, while female HIV-levels almost halved from 7.70% to 3.99%.

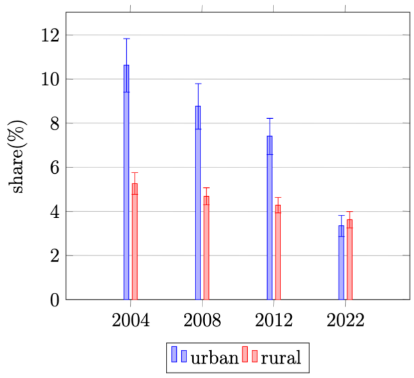
Figure 6b shows that the reduction in HIV prevalence is driven by a reduction the age groups of 20-44, particularly 25-29 years. The share of individuals testing positive for HIV could be reduced from 5.23% to 1.02% for the age group of 20-24 years, 8.3% to 1.43% for 25-29 years, 10.86% to 3.2% for 30-34 years, 10.75% to 5.2% for 35-39 years and 10.94% to 6.78% for 40-44 years. This corresponds to a decrease of 80.5%, 82.8%, 70.6%, 51.7%, and 38% respectively. Contrary, HIV rates have risen in the age groups of 45-49 years from 6.26%



(a) Gender



(b) Age



(c) Residence

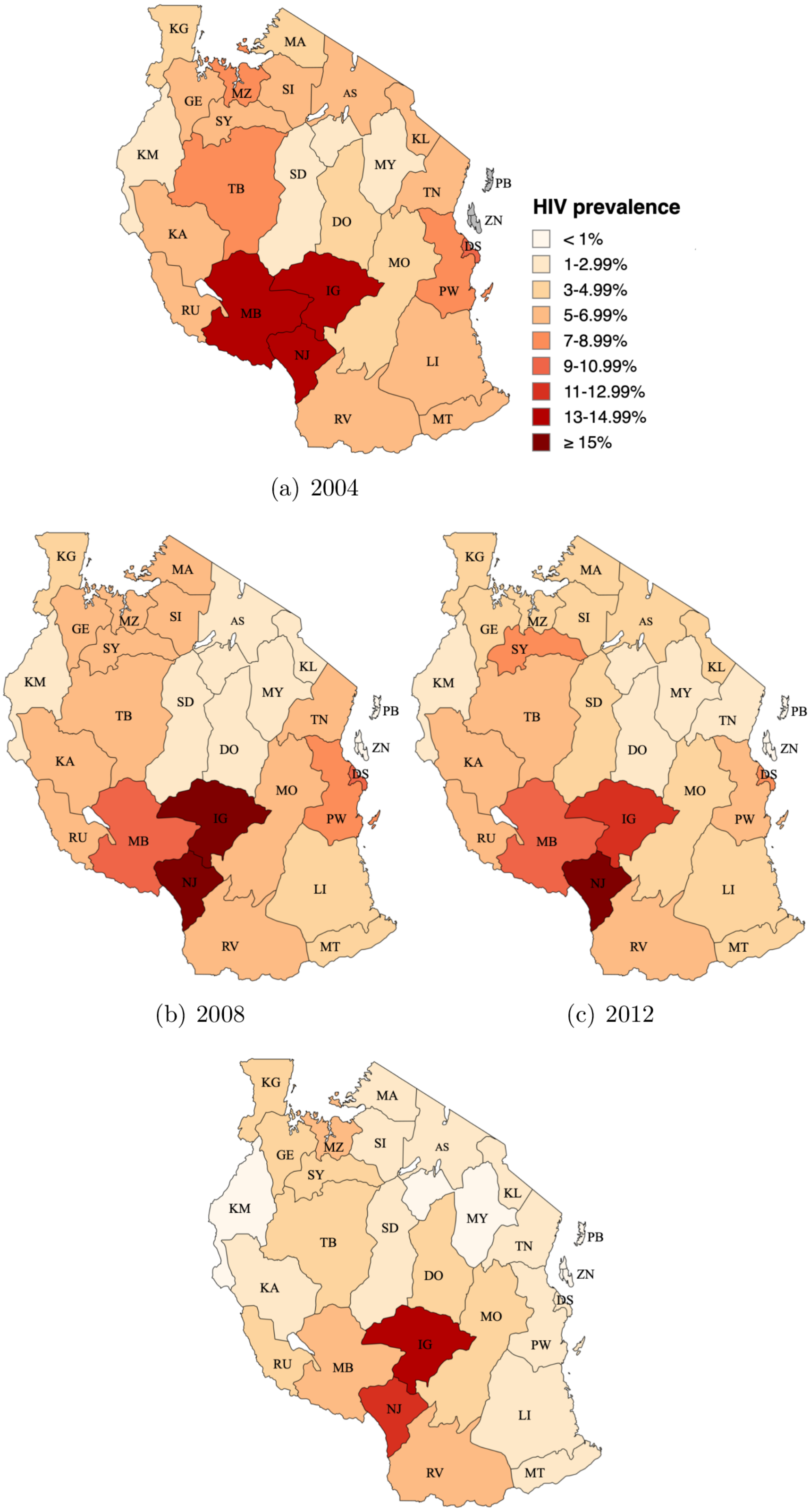
Figure 6: HIV prevalence according to gender, age, residence, 2004-2022

in 2004 to 7.92% in 2022. However, it has to be noted that this difference is not significant and that individuals, if already infected in 2004, belonged to the age groups 25-29 and 30-34 years back then, which represented the overall peak in HIV prevalence. Alarmingly, HIV levels in the youngest age group of reproductive age (15-19 years) have risen slightly between 2008 and 2022, but seem to remain on a stable level. Looking at the 2022 data only, the picture shows a positive picture for the future as the HIV prevalence is declining the younger the age group.

Between 2004 and 2012, HIV prevalence has been higher in urban areas than in rural ones (Figure 6c). Significant between 2004 and 2012, the difference between rural and urban residence became insignificant after 2012 and the data shows urban HIV levels to be lower than in rural areas in 2022. In 2004, the share of HIV positive individuals of reproductive age in rural areas (5.27%) was more than half of the share in urban areas (10.63%). However, while rural HIV prevalence has decreased slightly from 5.27% to 3.63% between 2004 to 2022, urban HIV levels dropped remarkably from 10.63% and were even on a lower level in 2022 (3.35%). This is mostly due to progress in the last decade, in which HIV prevalence in urban settlements could be more than halved.

Figure 7 shows that HIV prevalence varies by region and that the reduction in HIV rates over time is mainly driven by regions in the Eastern and Western part of the country. The regions of Iringa and Njombe remain the areas hardest hit with HIV levels of 13.41% and 11.64% respectively. However, HIV prevalence has decreased for these regions as well since its peak of 15.69% in 2008, when both regions still constituted one common region. The regions with the highest HIV prevalence coincide with the regions that have the highest testing rate (Figure 3). Unfortunately, the DHS does not provide enough data to analyze if the prevalence is as high due to the high testing rate or if the testing rate is as high due to the high HIV prevalence.

HIV incidence in Tanzania in 2021 was at 0.56% for the whole population of reproductive age. It was significantly higher for females who had an estimated incidence of 0.64% com-



(a) 2004

(b) 2008

(c) 2012

(d) 2022

Figure 7: HIV prevalence according to region, 2004-2022

pared to males with an HIV incidence level of 0.27%. HIV incidence in 2021 was lowest for the youngest age groups with 0.34% for individuals aged 20-24, 0.20% for individuals aged 25-29 and 0.34% for individuals aged 15-19. The highest HIV prevalence was observable in the age groups 35-39, 30-34 and 40-44 with levels of 0.82%, 0.98% and 0.77% respectively. Consistent with overall HIV prevalence, HIV incidence in 2021 was higher in urban areas with 0.64% than in rural areas where HIV incidence was estimated to be 0.52%. However, this difference is not significant. As the DHS survey was conducted from March to July 2022, information on HIV incidence in 2022 is not available.

4.2.3 ART coverage

Data on ART coverage is provided for the DHS cohort of 2022 only. In 2022, 96.35% of all HIV-infected individuals of reproductive age received treatment. Coverage across genders was similar and differences not statistically significant with 97.5% males and 96.19% of females being on an ART regime.

Similarly, ART coverage in people knowingly being infected with HIV is high across all age groups of reproductive age with no significant differences observable. Meaningful estimations cannot be carried out for the age groups of 15-19 and 20-24 years, as there are less than 30 individuals in both age groups that have given information about their ART intake. All other age groups have an ART coverage of at least 95% except the group 35-39 years which is slightly below (93.50%). However, the estimates have to be interpreted with caution as the sample sizes are between 41 (25-29 years) and 125 observations (40-44 years).

There is also no significant difference in ART intake according to residence with 95.1% of urban HIV-positive individuals and 96.9% of rural HIV-positive individuals being on treatment. A differentiation according to region is not possible due to too small sample sizes.

The above presented findings are interesting as Mnzava et al. (2018) found costs to be the major obstacle to ART uptake in Tanzania. Their study found out-of-pocket expenditures in order to obtain ARTs in Tanzania to be significantly higher for females and rural residents. However, this study shows a high ART coverage with only insignificant differences between genders and area of residence. This indicates that challenges in accessing ARTs in Tanzania might not be as severe.

4.2.4 Knowledge of mother-to-child transmissions

As mentioned above, vertical HIV transmissions are one main source of spreading HIV. The following section will provide a brief picture of the knowledge of mother-to-child transmissions in the Tanzanian population between 1996 and 2012. Questions about the knowledge regarding mother-to-child transmissions were not asked in the 2022 DHS and 2012 data is thus the most recent.

Awareness about mother-to-child transmissions seems to vary greatly over time. While the share of individuals that were aware that HIV could be transmitted to the fetus during pregnancy could be increased from 45.06% in 1996 to 93.63% in 1999, this number decreased again over the following years (Figure 8). While the share varied between 2004 and 2010, the latest numbers from 2012 reveal that only 77.63% of all individuals of reproductive age are aware of vertical transmissions during pregnancy. This trend is also observable for knowledge about vertical transmissions during delivery and breastfeeding period. Even though awareness increased in the late 1990s, it experienced a slight decrease in the 2000s although not as large as the awareness of transmissions during pregnancy. In 2012, people were most aware of mother-to-child transmission during breastfeeding (87.82%) compared to transmission during delivery (77.49%) and pregnancy (77.63%). These trends do not differ according to gender, while younger age groups as well as rural residents seem to be less aware of all forms of vertical transmission. In general, awareness is higher in HIV-positive individuals of reproductive age. Alarmingly, also these estimates are still low with only 72.54% being aware of transmission during pregnancy, and 78.17% during delivery and 89.07% during breastfeeding in 2012.

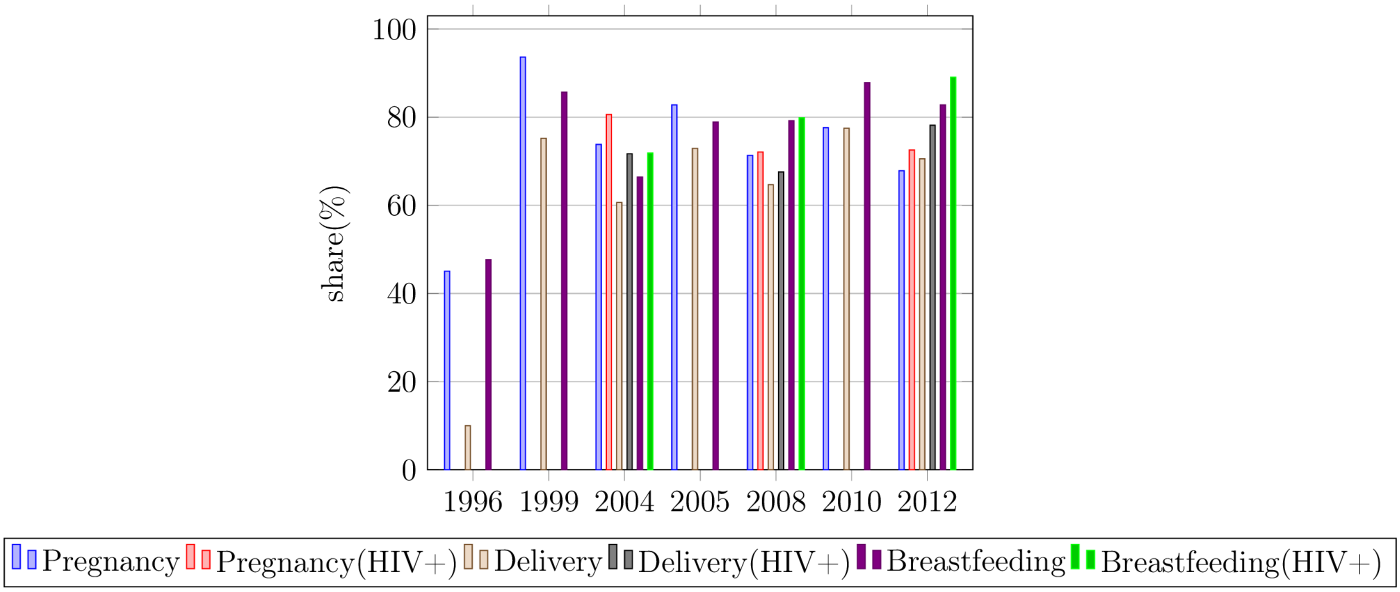


Figure 8: Knowledge about mother-to-child transmission during pregnancy, delivery and breastfeeding period, 2004-2022

ARTs are used widely to prevent vertical transmissions during pregnancy, however, there is still little knowledge in the Tanzanian population that they can also be used for this purpose and not only for hindering the disease to progress. In 2004, only 21.04% of adults of reproductive age knew about the existence of ARTs to prevent vertical transmissions by certainty (Figure 9). This number could be raised to 78.51% in 2010, while 2022 data shows that only 67.23% of adults of reproductive age are aware that ARTs can be administered to prevent mother-to-child transmissions. Contrary, and more importantly, the awareness about the use of ARTs to prevent mother-to-child transmissions, has constantly been rising in HIV positive individuals. Starting off at a share of 25.85% in 2004, this number could be increased by more than 3.5 times to 90.15% in 2022. The knowledge is slightly higher in females that tested positive for HIV compared to males, where 91.67% of all HIV-positive females of reproductive age answered to know that ARTs can be used to prevent vertical transmissions.

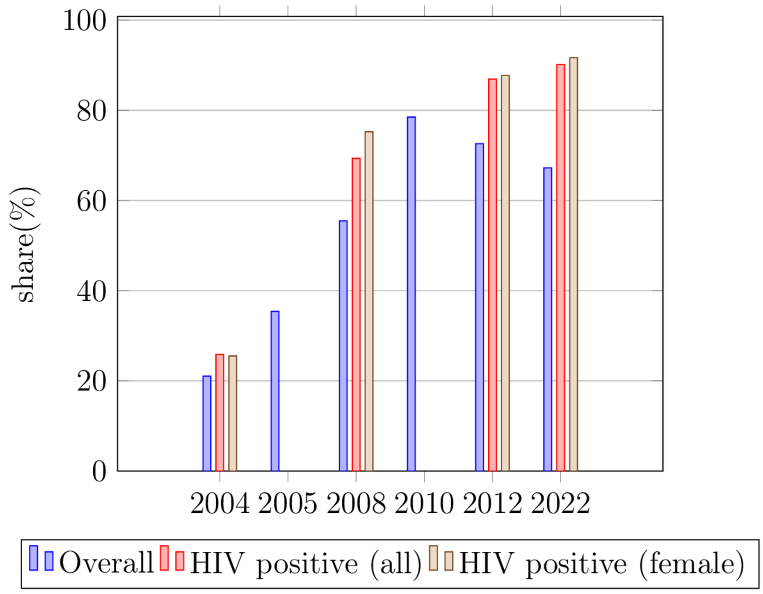


Figure 9: Knowledge about ART use to prevent mother-to-child transmissions, 2004-2022

4.2.5 Summary

In total, there has been substantial progress in decreasing HIV prevalence in Tanzania over the last two decades. However, rates remain at a moderate level of 3.51% in 2022. Prevalence is highest in females of older age groups which are at the same time the groups with the highest incidence in 2021. The regions of Iringa and Njombe remain the regions hardest hit by the HIV/ AIDS epidemic in terms of prevalence. Testing rates remain on a low level despite progress in the past years. In 2022, only 73.18% of the population of reproductive age had ever been tested for HIV. This is far from the UN target of 95% testing rate until 2025, which will most probably not be reached without appropriate measures being taken. Testing is especially low in males, the youngest age groups, and rural residents which show the most potential in increasing test rates. However, no age group or gender has reached the first 95% goal of the UN, requiring a scaling up of testing for all groups of society. Testing rates during pregnancy are on a high level with over 90% of women being tested for HIV as part of one antenatal visit. Out of the people diagnosed with HIV, 96.35% are on ART, achieving the second 95% goal of the UN already now. The data shows that ART coverage does not vary significantly by age, gender or residence. There are large gaps in knowledge on mother-to-child transmissions, both in the general population as well as in HIV positive individuals. In order to decrease the number of new infections, campaigns and interventions in providing information on ways of transmission should be scaled up. As the DHS does not provide any information on viral load, no conclusion can be made about the third 95% goal of the UN (Suppression of the viral load). SDG target 3.3 of ending the HIV/ AIDS epidemic by 2030 sets the goal of limiting HIV incidence to 0.5% by 2025 and 0.25% by 2030 WHO (n.d.-c). While the HIV incidence in the overall population in 2021 (0.56%) does not comply yet with the 2025 goal, it differs according to gender. Male HIV incidence (0.27%) complied with the 2030 target already in 2021, while female levels (0.64%) remain higher and still need to be decreased further in order to reach the 2025 target for this group.

4.3 Child malnutrition

According to the WHO (2014b), malnutrition *"includes undernutrition (wasting, stunting, underweight), inadequate vitamins or minerals, overweight, obesity, and resulting diet-related noncommunicable diseases"*. As thesis focuses on undernutrition in children under the age of five, wasting, stunting and underweight as consequences of undernutrition in Tanzanian children will be explored in more detail.

Wasting, measured in weight-for-height, refers to a recent and acute loss of weight due to insufficient food intake or infectious diseases (WHO, 2014b). Although treatable, wasted children are at a higher risk of contracting infectious diseases due to impaired immune system function (WHO, n.d.). This condition poses a greater risk for noncommunicable diseases as diabetes, certain types of cancers and cardiovascular illnesses (WHO, n.d.).

Repeated as well as chronic undernutrition is defined as *stunting*, measured in height-for-age (WHO, 2014b). It is usually a result of the socioeconomic environment, repeated diseases, maternal health status and/ or poor feeding practices. Contrary to wasting, stunting is a measure of long-term malnutrition and reflects thus the above mentioned conditions since before birth (WHO, 2014b), (WHO, n.d.). Stunting impairs a child's cognitive as well as physical abilities irreversibly and prevents them from reaching their full potential, affecting economic productivity in the long-run (WHO, 2014b).

Underweight is measured in weight-for-age and thus a composite indicator of stunting and wasting. Underweight children may be classified as both stunted and wasted or only one of them (WHO, 2014b). It gives consequently a picture of general undernutrition, but is more difficult to interpret than stunting and wasting (Magadi, 2011-a).

In 2006, the WHO published the WHO Child Growth Standards for children in order to assess a child's growth pattern by comparing it with international growth standards of healthy children. This tool helps to detect abnormal growth in children under the age of five, regardless of their ethnic background, socioeconomic conditions or feeding practices (WHO et al., 2006). A child is defined as stunted, wasted or underweight, in case their individual height-for-age, weight-for-height or weight-for-age score respectively is "more than two standard deviations below the corresponding international growth standard median", (WHO, n.d.). The DHS Datasets for 2010, 2015-2016 and 2022 provide information on the deviations from the international growth median and can thus be used to assess undernutrition in children under the age of five according to WHO standards. For the years before 2006 up until 2016, the DHS provides data on anthropometric growth failure by comparing a child's growth pattern to Growth Standards of the US Centers for Disease Control and Prevention (CDC). Similar to the WHO Growth Standards, the CDC Growth Standards also classify undernutrition in children by using deviations from the population median. However, the CDC set this cutoff value to the 98th percentile, translating to 2.05 standard deviations from the median (CDC, 2022). One shortcoming of the CDC Growth Standards is, that they are based on the US population only and do not allow to compare a child's growth pattern to international standards (CDC, 2022). In order to assess the long-term trend in malnutrition between 1992 and 2016, this thesis will refer to the CDC Child Growth measure. However, the prevalence of undernutrition in the country for more recent years will be assessed in more detail using the international WHO Child Growth Standards.

Even though the anthropometric indicators mentioned above allow to differentiate between acute and chronic undernutrtition, they do not give an overall estimate on how many children are undernourished. A child classified as stunted might but does not have to be wasted as well. Underweight captures both short- and longterm malnutrition but does not allow to differentiate if it is the same children being wasted and/ or stunted. Additionally, the conventional indicators fail to give an estimate on how many children suffer from severeal anthropometric growth failures. The Composite Index of Anthropometric Failure (CIAF) solves this issue by providing an estimate on the share of children that suffer from at least one form of growth failure (Nandy & Svedberg, 2012). According to Nandy and Svedberg (2012), the CIAF is calculated with the following formula:

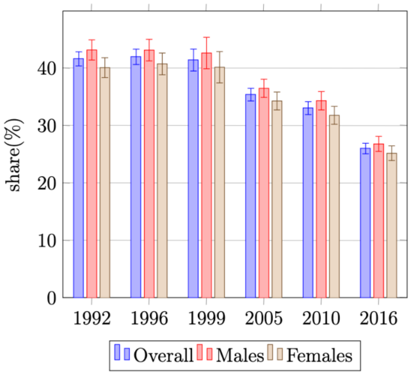
$$CIAF = (1 - A)/(A + B + C + D + E + F) = (1 - A)/(1) = 1 - A$$

with A representing the share of children without any anthropometric failure and B - F the share of children being wasted only (B), wasted and underweight (C), wasted, stunted and underweight (D), stunted and underweight (E), stunted only (F). As stunting, wasting and underweight prevalence measured with international growth standards (WHO Child Growth Standards) are available for the years 2010, 2015-2016 and 2022 only, the CIAF caculation will be restricted to these cohorts only.

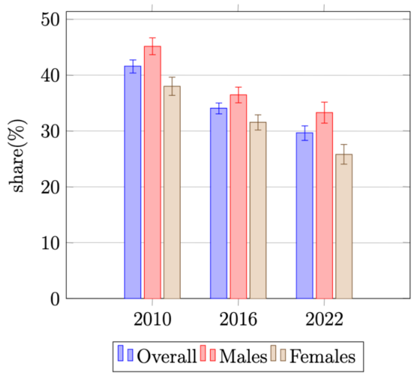
4.3.1 Stunting

Overall, stunting rates in Tanzanian children under the age of five have decreased remarkably since 1992, but remain on a high level. Between 1992 and 2016, the share of stunted children fell from 41.63% to 26.0% as can be seen in Figure 10a. This trend also holds for the years 2010 to 2022, using the WHO Children Growth Standards, in which stunting rates decreased from 41.59% to 29.66% (Figure 10b). Stunting rates for males and females reduced both, however, female stunting levels in children under the age of five are lower than in males at all times. While there were no significant differences by gender using the CDC Child

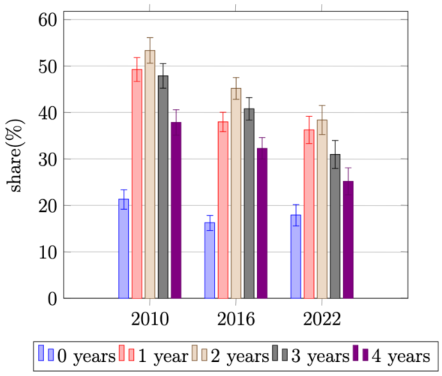
Growth Standards, the WHO Child Growth Standards show a significantly higher stunting prevalence in males. In 2022, 25.85% of all female children under the age of five were classified to be stunted while it was 33.33% for the male equivalent.



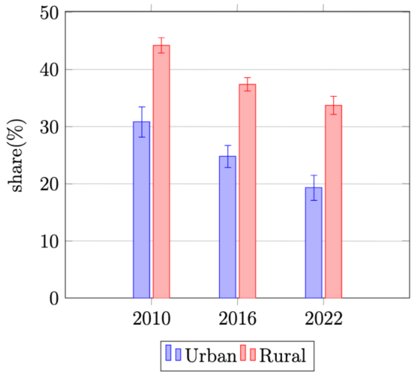
(a) Gender, CDC



(b) Gender, WHO



(c) Age group



(d) Residence

Figure 10: Stunting prevalence according to CDC, WHO, age group, residence, 1992-2022

Figure 10c shows that the reduction in stunting rates between 2010 and 2022 includes all age groups. Stunting prevalence in children aged zero (0-11 months) is substantially and significantly lower than in children aged one to four across all time periods. However, as stunting indicates long-term malnutrition, this is not unexpected as there is less time for malnutrition to chronify. Stunting levels in children under the age of one seem to have stabilized at under 20%, while the remaining age groups still show a downwards trend. Between 2010 and 2022, stunting was highest in children aged two (24-35 months).

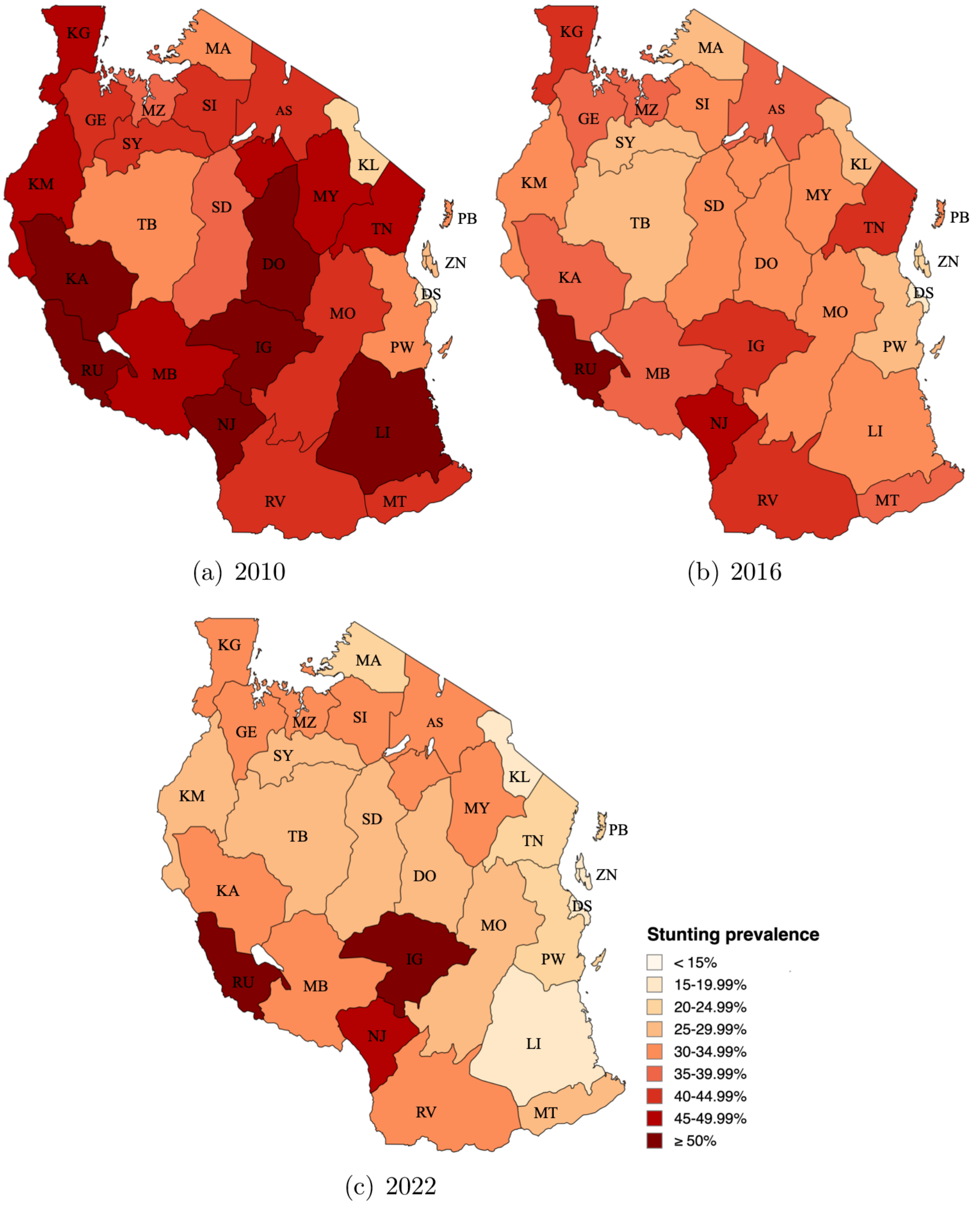
Stunting prevalence in rural areas have been on a significantly higher level than in urban areas (Figure 10d). Rural stunting rates could be reduced from 44.24% in 2010 to 33.75% in 2022, while urban stunting rates decreased from 30.83% to 19.32% in the same period. However, the difference in rates did not seem to diverge or converge within the decade shown in the graph.

Stunting levels vary by region (Figure 11), and the Southwest of the country remains to be hardest hit. Despite overall progress in the last decade, stunting levels still remain over 50% in the regions of Iringa and Rukwa in 2022. Progress has been achieved especially along the coastline (Eastern part) and in the center of the country.

4.3.2 Wasting

As Figure 12a shows, wasting rates declined on average from 5.70% to 3.76% between 1992 and 2016 among Tanzanian children under the age of five. After initially increasing from 1992 to 1996, wasting rates decreased until 2005. In fact, they more than halved from 6.79% in 1996 to 2.89% in 2005. The rise in wasting rates in 2010 coincides with the global food crisis 2007-2008 and its lasting effects on food prices (United Nations, 2011). As wasting captures short-term undernutrition, it is more sensitive to acute food emergencies compared to stunting. Since 2010, wasting levels have been on a downwards trend again in terms of WHO Child Growth Standards (Figure 12b). Much progress has been made in the last decade as overall wasting prevalence could be almost halved from 4.85% in 2010 to 3.22% in 2022. Similar to stunting patterns, wasting rates of male children under the age of five have been on a consistently higher level than in females but follow the same trend. However, this difference is insignificant for 2022.

Looking at the wasting prevalence according to age, wasting levels have decreased for almost all age groups between 2010 and 2022 (Figure 12c). The youngest children are most adversely affected with children aged zero (0-11 months) having the highest wasting prevalence in 2010 and 2016 while children aged one (12-23 months) were the most affected group in 2022. It is mostly these two groups, especially children aged zero, that are the



(a) 2010

(b) 2016

(c) 2022

Figure 11: Stunting prevalence in 2010, 2016 and 2022

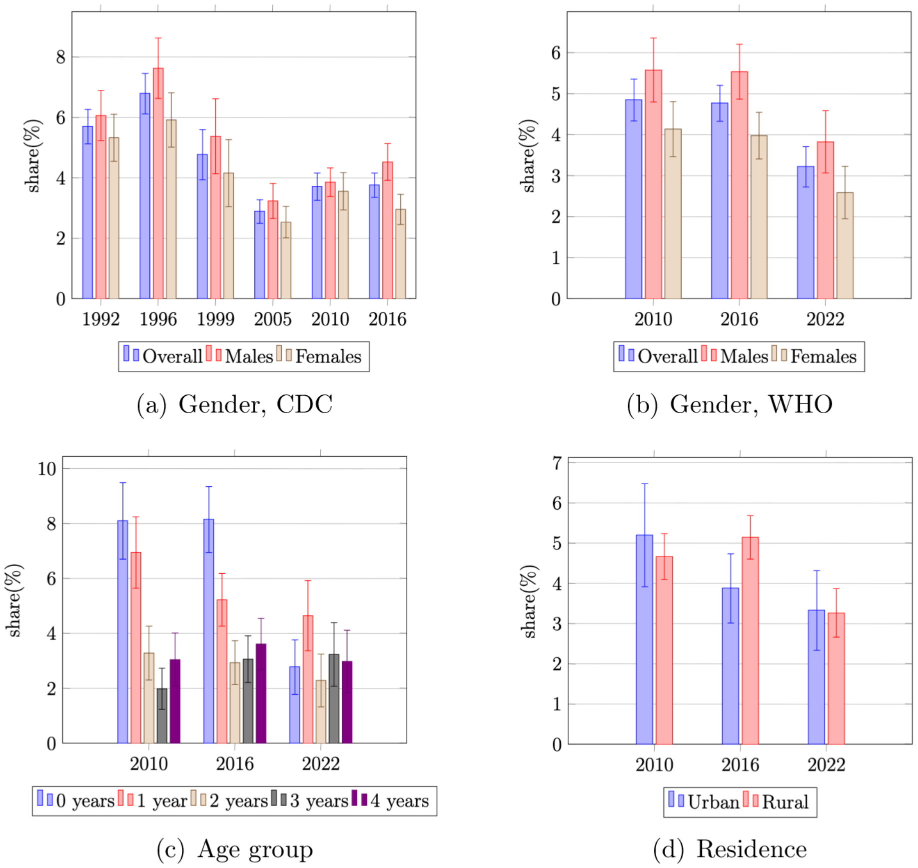


Figure 12: Wasting prevalence according to CDC, WHO, age group, residence, 1992-2022

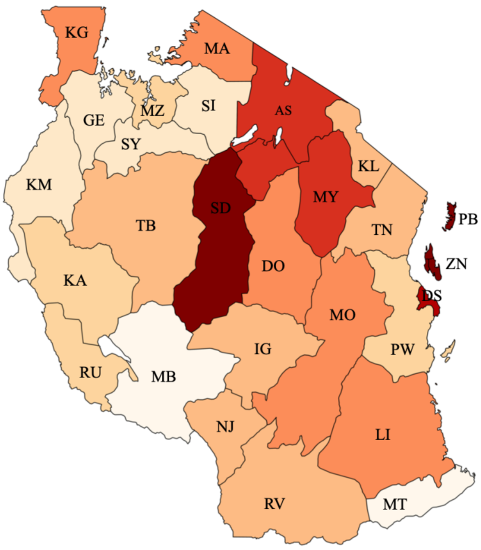
main driver of the overall reduction for all children. Wasting levels for the youngest age group could be reduced from 8.1% in 2010 to 2.78% in 2022, reflecting remarkable progress in reducing wasting levels for infants over the last decade. However, wasting prevalence has increased insignificantly in children aged three (36-47 months) from 1.99% in 2010 to 3.24% in 2022.

Wasting levels according to residence follow the overall trend of a reduction in child wasting. Wasting is still more prevalent in rural than in urban areas, but differences are insignificant (Figure 12d). The reduction in wasting in urban areas was mostly achieved between 2010 and 2022 (5.20% to 3.33%), while it happened between 2016 and 2022 in rural areas (4.67% to 3.27%).

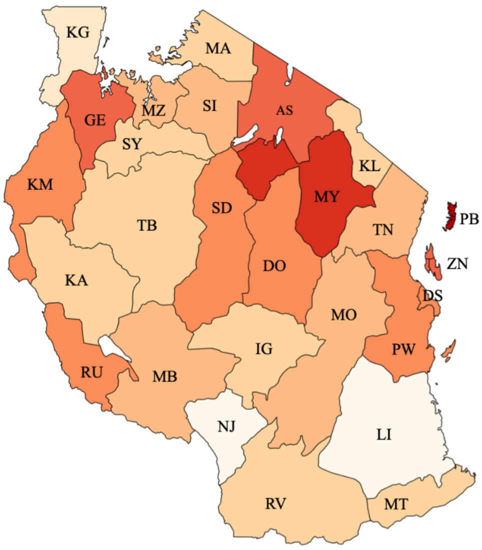
The trend in wasting levels varies by region, with some regions like Singida and Pemba experiencing an overall drop in wasting prevalence between 2010 and 2022, while other regions like Rukwa and Pwani experienced an increase during the same time. Some regions like Zanzibar experienced a reduction from 2010 to 2016, but then fell back to high wasting rates in 2022 (Figure 13). Overall, it seems like the wasting prevalence has decreased and that there are no geographical patterns observable.

4.3.3 Underweight

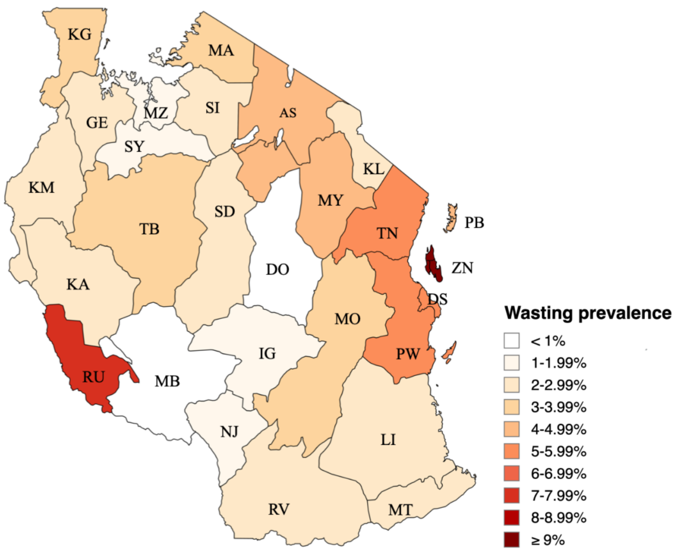
Underweight prevalence in Tanzania has been decreasing since 1996, both for all children combined as well as males and females as Figure 14a shows. The CDC Growth Standard Measure does not reveal that underweight patterns between genders differed significantly and systematically between 1992 and 2010. However, it is mostly males that show higher underweight rates. Although underweight as a composite indicator captures both stunting and wasting, the peak in stunting rates 2010 due to the international food crisis mentioned above is not visible. However, progress seems to have stalled between 2005 and 2010. The WHO Child Growth Measure shows that male underweight rates in 2010 and 2022 are significantly higher than female underweight rates between 2010 and 2022 (Figure 14b).



(a) 2010



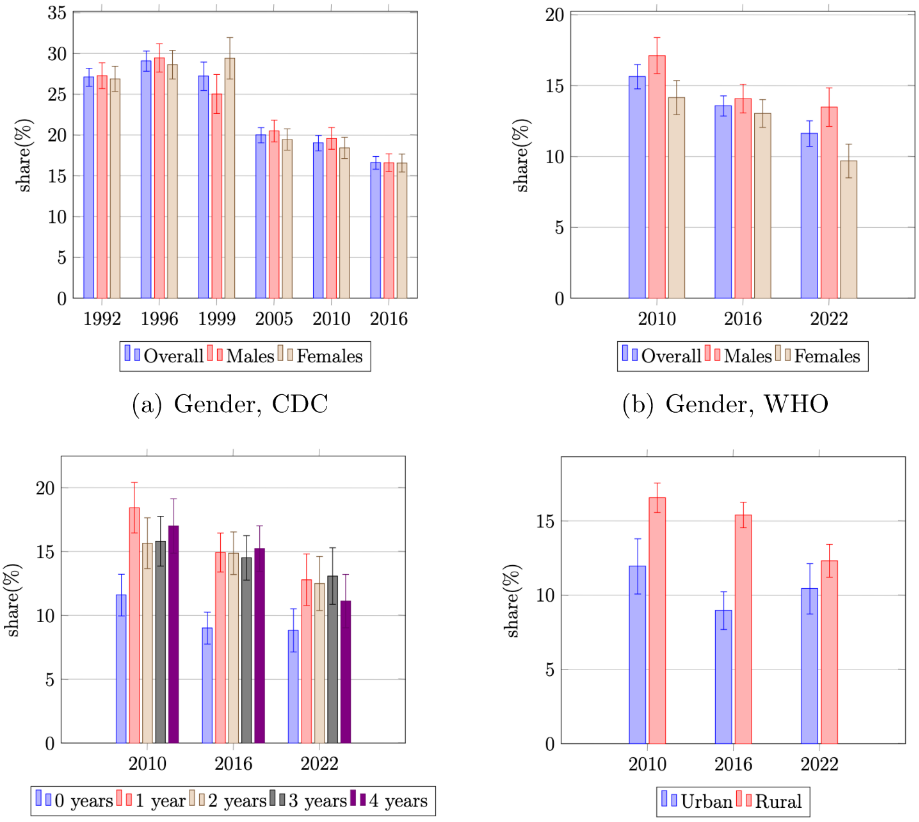
(b) 2016



(c) 2022

Figure 13: Wasting prevalence in 2010, 2016 and 2022

Within the last decade, underweight levels could be reduced by almost one third, regardless of gender.



(a) Gender, CDC

(b) Gender, WHO

(c) Age group

(d) Residence

Figure 14: Underweight prevalence according to CDC, WHO, age group, residence, 1992-2022

Separating underweight levels according to age group, underweight is significantly less prevalent in children aged zero (0-11 months) than in the remaining age groups (Figure 14c). Being a composite indicator of stunting and wasting, this could be due to the patterns in stunting described above, as stunting levels are lowest for this age group. Underweight levels have been decreasing in all age groups, with most of the progress attributed to children aged one to four.

Underweight is significantly more prevalent in rural than in urban areas for the years 2010 and 2016 as shown in Figure 14d. Also in terms of residence, underweight levels have been decreasing on average between 2010 and 2022. The share of rural underweight children under the age of five has decreased continuously and significantly from 16.57% in 2010 to 12.33% in 2022. However, urban underweight levels have been decreasing from 11.95% in 2010 to 8.97% in 2016, but experienced an increase until 2022 (10.44%) and the difference over time is insignificant. Interestingly, this trend is not observable for either stunting or wasting, even though underweight acts as a composite indicator.

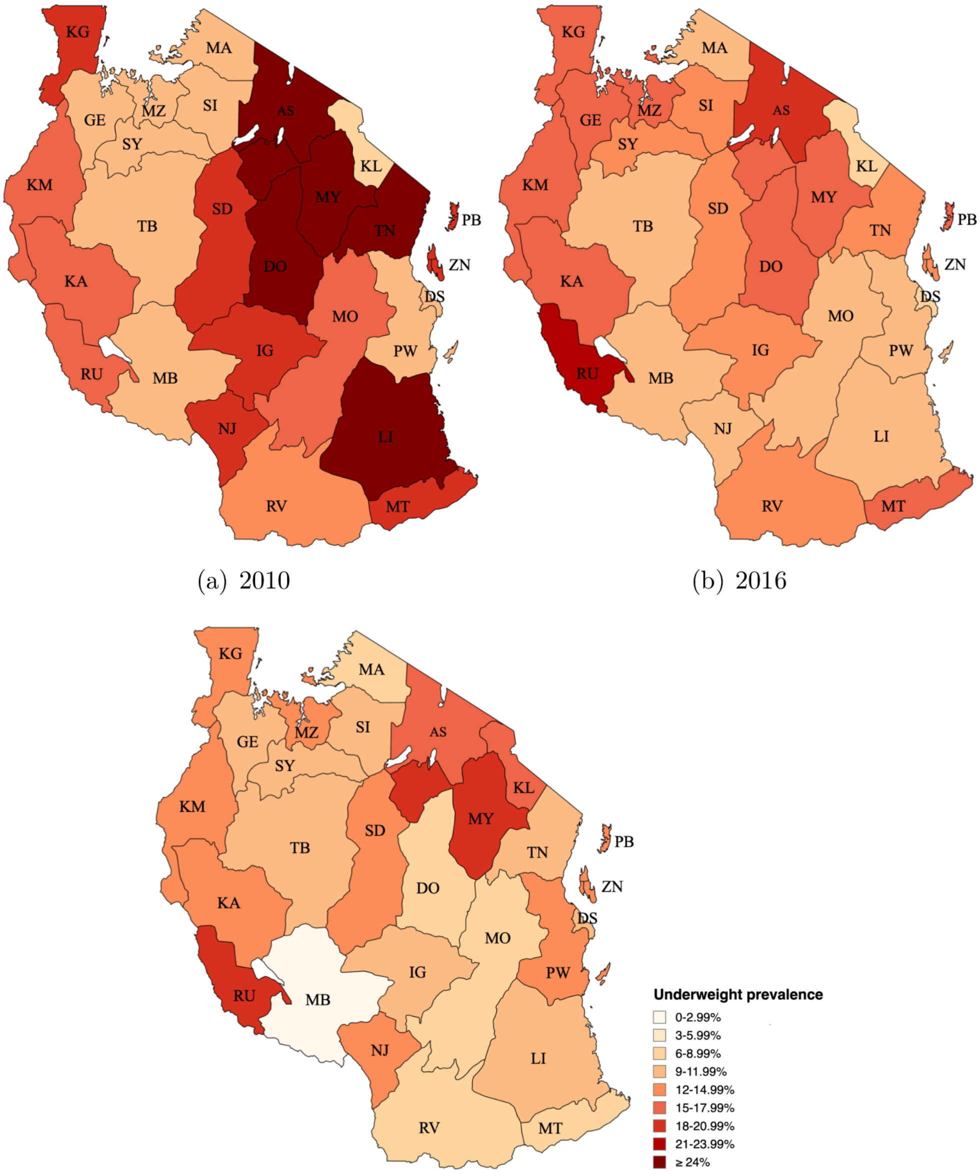
Although Figure 15 visualizes the overall reduction in underweight rates, this is not true for all Tanzanian regions. Especially the regions in the Northeast and West of the country remain hardest hit. However, the majority of regions was able to reduce underweight prevalence from 2010 levels.

4.3.4 CIAF

The CIAF estimates overall undernutrition in the country and is based on the three indicators analyzed above. The share of Tanzanian children under the age of five suffering from at least one form of undernutrition decreased continuously from 2010 to 2022 regardless of gender (Figure 16a). While almost half of all males (49.40%) under the age of five were estimated to suffer from at least one form of malnutrition in 2010, this number decreased significantly by almost one third to 37.41%. Female rates decreased slightly less, but still significantly from 41.68% in 2010 to 29.08% in 2022. This translates to an overall, statistically significant, reduction from 45.52% of children being undernourished to 33.33% of children being undernourished. However, overall undernutrition remains on a high level despite the progress since 2010. Almost every third child under five living in Tanzania is suffering from at least one form of undernutrition in 2022.

Overall undernutrition decreased for all children under the age of five between 2010 and 2022, but this reduction was mainly driven by children over the age of zero (12+ months) (Figure 16b). Undernutrition prevalence is highest in children aged two to four.

The share of children suffering from at least one form of malnutrition is significantly

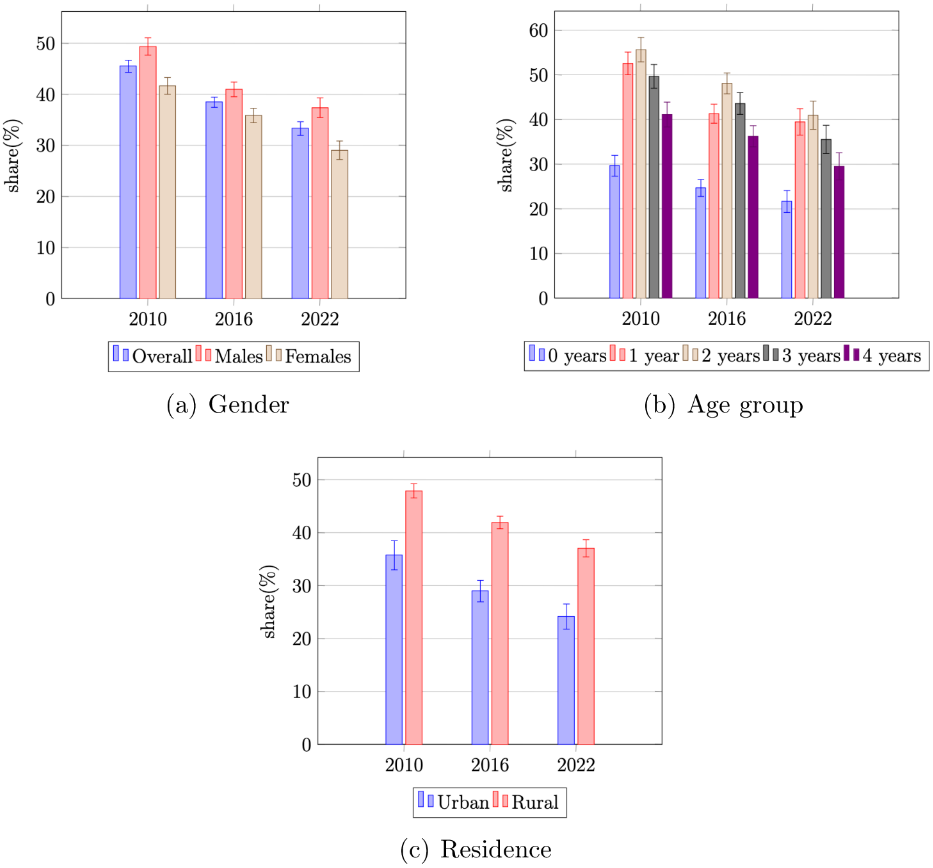


(a) 2010

(b) 2016

(c) 2022

Figure 15: Underweight prevalence in 2010, 2016 and 2022



(a) Gender (b) Age group

(c) Residence

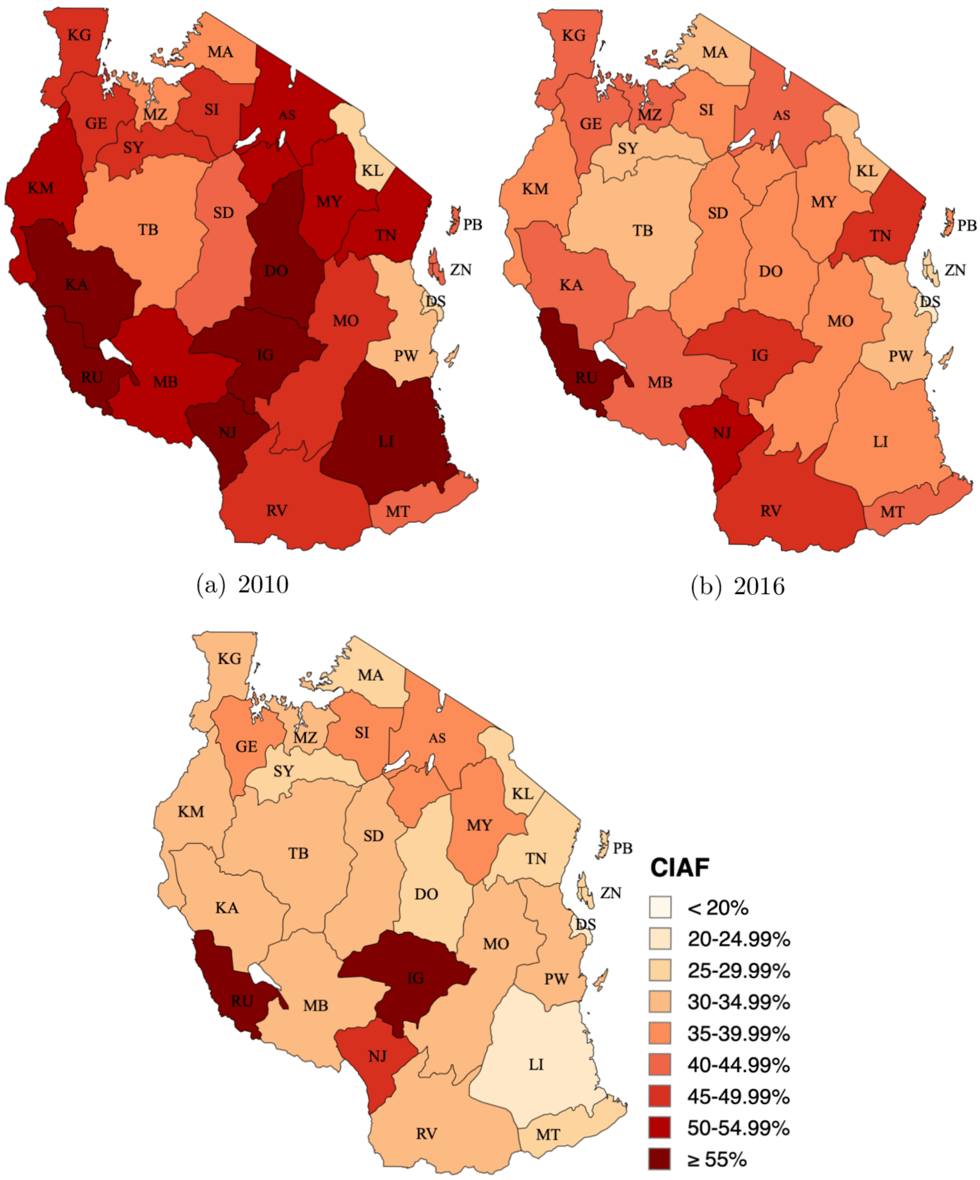
Figure 16: CIAF according to gender, age group, residence, 2010-2022

higher in rural areas than in urban ones, but has decreased significantly for both types of residences. While urban rates could be decreased from 35.76% in 2010 to 24.19% in 2022, rural undernutrition rates decreased from 47.92% to 37.08% during the same period (Figure 16c).

As stunting, wasting and underweight levels decreased between 2010 and 2022, it is consequently no surprise that the share of children under five suffering from at least one form of malnutrition also decreased over time. This trend of an overall decrease of children suffering from at least one form of malnutrition can also be observed when looking at the variation by region (Figure 17). Although almost all regions have made some progress since 2010, child undernutrition levels remain high in the whole country. In 2022, undernutrition levels were highest in Iringa and Rukwa where every second child is estimated to suffer from at least one form of malnutrition. Even in Lindi, the region with the lowest undernutrition prevalence, every fifth child (21.84%) is estimated to suffer from at least one form of undernutrition. However, substantial progress has been made in most of the regions within the last decade. This becomes especially visible when visually comparing 2010 data with 2022 data.

4.3.5 Summary

Despite remarkable progress in reducing child undernutrition in Tanzania, stunting, wasting and underweight rates remain on a high level. Almost every 4th child is estimated to be stunted with males, children aged 1 or older, rural residents and children living in the Southwestern regions of the country being at the highest risk. In the regions of Iringa and Rukwa, more than every second child is estimated to be stunted. Wasting prevalence is estimated to be 3.6% in 2022. Contrary to the risk of stunting, the youngest children as well as males are at the highest risk of being wasted, while there was no clear patterns in terms differences by residence and region. Similar to stunting risk, underweight prevalence is highest in males, children older than 11 months, rural residents and children living in Northeastern and Western parts of the country. In 2022, underweight prevalence was estimated to be 11.63%. The



(a) 2010

(b) 2016

(c) 2022

(d) Legend

Figure 17: CIAF in 2010, 2016 and 2022

CIAF also captures the progress being made since 2010, however, more than one third of all Tanzanian children under the age of five are estimated to suffer from at least one form of undernutrition. This is a substantial reduction from almost every second child (45.52%) in 2010. Target 2.2 of the SDGs, aiming at ending malnutrition by 2025, also sets goals for reducing stunting and wasting prevalence. According to WHO (2014a), stunting prevalence should be reduced by 40% until 2025, while wasting levels should be kept under 5%. Stating at an initial level of 41.57% in 2010, stunting levels could be reduced to 29.66% in 2022, translating to a reduction of 29.7%. This calls for urgent action to achieve the target for stunting by 2025. However, the target for wasting could be reached with an estimated share of 3.6% of all children under the age of five to be wasted.

5 Empirical strategy

5.1 Data

The following analysis of the relationship between HIV exposure and undernutrition of Tanzanian children under the age of five is based on DHS Data for Tanzania collected during the year 2022. This dataset is the only DHS data available for Tanzania that contains both information on anthropometric measures of children under the age of five as well as information on the mother's HIV status. Previous DHS cohorts only provide information on HIV status (2004, 2008, 2012 cohorts) or data regarding the nutritional status of children (1992, 1996, 1999, 2005, 2010, 2016 cohorts). Other surveys apart from the DHS survey collecting information on both child anthropometric status and parental HIV status are not available for Tanzania. For the 2022 DHS cohort, 15,705 households were surveyed consisting of a total of 15,254 women and 5,763 males of reproductive age (15-49 years). As displayed in an earlier part of this thesis (Table 1), fieldwork was carried out between March and July 2022. Children born to HIV-positive fathers are not considered for the purpose of this thesis. Information on child nutritional status are collected through surveying the mother and information about the father is thus not always available, especially in households where both parents are not living together anymore.

Not all households surveyed for the DHS are eligible for HIV testing and/ or collection of anthropometric data. Restricting the sample to children under the age of five where maternal HIV status is available, 567 observations had to be dropped, so that a sample size of 10,216 children under the age of five remained. Data on stunting, wasting and underweight is available for 4,529, 4,552 and 4,553 children respectively.

5.2 HIV exposure

One shortcoming of the DHS with regards to HIV testing is that HIV status is only determined for adults of reproductive age (15-49 years) and thus not for children under the age of five. Child HIV status can therefore not be determined definitely based on DHS data. Magadi (2011-a), also carrying out secondary analysis of DHS data, does not differentiate according to HIV exposure and includes all children regardless of HIV status in her study. Including all children born to HIV-positive mothers would however bias the estimations as paediatric HIV infections often lead to undernutrition (Koethe & Heimburger, 2010) as described in Section 2. Also other population-based surveys as the Tanzania Health Impact Survey (THIS) do not allow differentiating based on child HIV status or do not provide information on child nutritional status.

As described above, Lyatuu et al. (2023) find vertical transmission risk to be as low as 1.4% in Tanzanian children born to HIV positive women when complying with ART intake. Their study followed children until the age of 18 months, which they consider to be the cutoff for mother-to-child transmission risk. Even in women starting on an ART regime in a later stage of pregnancy, they estimate transmission rates to be below 3%. Also other studies have found mother-to-child transmission rates under ART intake to be slightly above 1% in breastfeeding individuals (Shapiro et al., 2013) or even below 1% in populations that do not breastfeed their children (Forbes et al., 2012). Given the high HIV testing rate during pregnancy described in Section 4.2.1 , the major share of pregnant HIV-positive women in Tanzania is aware of their status. Investigating the obstacles to ART access in Tanzania, Mnzava et al. (2018) find out of pocket expenses to be the major obstacle of ART access. However, the 6 MMD regime of dispensing ARTs, reducing out-of-pocket expenditures as transport costs and/ or opportunity costs, as well as the high ART prevalence shown in Section 4.2.3 show that obstacles to ART access in Tanzania are rather low. Based on the very low vertical transmission risk when taking ARTs during pregnancy, ART intake during pregnancy can be used as a proxy for HIV exposure. This is based on the following two assumptions: 1) No transmission of HIV when taking ARTs during pregnancy, based on the very low transmission rate shown by Lyatuu et al. (2023). 2) No horizontal HIV infections during this time, e.g., through blood transfusions and/ or exposure to contamination.

This study classifies children thus as being *HIV exposed* if their mother is HIV positive and on ARTs. Children whose mothers are HIV positive but do not take ARTs (n=8 (3.85% of potential HIV exposed children)) are excluded from the study as HIV exposure status cannot be determined. This leaves 208 children that can be considered as being HIV exposed. However, restricting the sample of HIV exposed children further to children that are born after the first positive HIV test, reduces the number of HIV exposed children further to 150 children. The 58 dropped observations were born before the first positive HIV test of the mother. As there is no information on when the last negative test was taken, it is not certain if an HIV infection was already present during pregnancy with these children. This leaves a sample size of 10,150 children in total.

5.3 Identification strategy

The analysis of malnutrition in HIV exposed children will be carried out in two steps. In a first step, simple mean as well as chi squared tests will be carried out to detect significant differences in the mean z-scores as well as undernutrition prevalence of HIV exposed and HIV unexposed children. In a second step, the relationship between undernutrition and

HIV exposure in Tanzanian children under the age of five will be determined by an OLS regression, also analyzing how the socioeconomic environment influences this relationship.

Indicators of undernutrition (*stunting, wasting, underweight*), measured in standard deviations below the WHO Child Growth Standard median, are provided by the DHS dataset. OLS regressions will be carried out for each of the indicators separately with a child's individual stunting/ wasting/ undernutrition z-score as the outcome of interest.

The variables used in the OLS regression are based on Magadi (2011-a)'s study on HIV exposed children in Sub-Saharan Africa. Besides HIV exposure and the socioeconomic status as explanatory variables, all other covariates are variables likely to be associated with the nutritional status of children. The covariates can be grouped into three categories: child, maternal, and community/ household characteristics. Child-level variables include age, sex, birth order, single birth, birth interval preceding birth (for birth order two and higher), if the child was ever breastfed, and the size at birth. Maternal-level variables included are education, age, and marital status. Household and community characteristics are comprised of the residence and wealth as a variable of the socioeconomic status. A detailed overview of all variables is provided in Table 3.

The regression analysis is based on the following general model:

$$(Z - Score_{i,r}) = \alpha + C_{i,r} + M_{i,r} + H_{i,r} + HIV_{exp} + WealthIndex + \alpha_i$$

with $(Z - Score_{i,r})$ indicating the height-for-age (stunting), weight-for-height (wasting) or weight-for-age (underweight) z-score for child i in region r. Child level characteristics are included in $C_{i,r}$, maternal characteristics in $M_{i,r}$, and household specific variables in $H_{i,r}$.

As shown in Section 4.2.2, HIV and undernutrition prevalence differ by region and the adverse effects of these two challenges might thus differ for each region. In order to account for a potential dependence of observations on regional level and thus a possible violation of the independence assumption, standard errors will be clustered on the regional level. The regression sample contains 160 observations for Iringa, the region with least observations, and allows thus for clustering while maintaining statistical power for each group. Clustering

		Definition
Dependent variables		
	Stunting z-score	Height-for-age standard deviations below/ above the WHO Child Growth Standards multiplied by 100
	Wasting z-score	Weight-for-height standard deviations below/ above the WHO Child Growth Standards multiplied by 100
	Underweight z-score	Weight-for-age standard deviations below/ above the WHO Child Growth Standards multiplied by 100
Explanatory variables		
	HIV exposure	Dummy variable; Coded as 1 = HIV exposed (i.e., child born to a HIV positive mother that is on ARTs); 0 = HIV unexposed
	Wealth Index	DHS Index of household wealth adjusted according to rural and urban residence (based on asset ownership, houseing materials and sanitation)
Child-level	Age	Ordinal variable; Current age of the child in months (0-59)
	Sex	Dummy variable; Coded as 1 = Male; 0 = Female
	Birth order	Dummy variable; Coded as 1 = 6th birth or above (above national average of 5.66 children); 0= 1st to 5th birth
	Multiple birth	Dummy variable; Coded as 1 = multiple birth; 0 = single birth
	Birth interval	Dummy variable indicating the birth interval preceeding birth; Coded as 1 = more than 24 months; 0 = 24 months or below; Defined as 1 for all firstborns
	Ever breastfed	Dummy variable; Coded as 1 = child was ever breastfed; 0 = child was never breastfed
	Birth size	Dummy variable; Coded as 1 = below average; 0 = average or above
Maternal & household level	Educational attainment	Dummy variable; Coded as 1 = at least completed primary education; 0 = no completed primary education
	Age	Ordinal variable; Current age of the mother in completed years (15-49 years)
	Marital status	Dummy variable; Coded as 1 = single; 0 = partnered or married
	Residence	Dummy variable; Coded as 1 = urban; 0 = rural

Table 3: OLS regression variables

	HIV unexposed children	HIV exposed children	p-value
Mean child age (months)	28.94 (28.60; 29.28)	26.18 (23.39; 28.97)	0.0540
Male share	50.87% (49.89%; 51.85%)	53.33% (45.26%; 61.41%)	0.549
Birthorder 3+	17.96% (17.21%; 18.71%)	26% (18.90%; 33.10%)	**0.011**
Preceding birth interval > 24 months	84.38% (83.67%; 85.09%)	88.67% (83.54%; 93.80%)	0.150
Share ever breastfed	95.87% (95.37%; 96.37%)	89.90% (83.86%; 95.94%)	**0.003**
Birthsize below average	8.01% (7.31%; 8.70%)	11.34% (4.92%; 17.76%)	0.231
Multiple births	3.3% (2.93%; 3.63%)	2.67% (0.06%; 5.27%)	0.675
Mean maternal age (Years)	29.45 (29.31; 29.58)	34.08 (32.99; 35.17)	**0.0000**
Completed at least primary education	80.14% (79.36%; 80.92%)	83.33% (77.30%; 89.37%)	0.330
Single parent	15.93% (15.21%; 16.65%)	37.33% (29.50%; 45.16%)	**0.000**
Urban residence	27.87% (26.97%; 28.76)	35.57% (27.79%; 43.35%)	**0.038**
Wealth below average	59.71% (58.75%; 60.67%)	58% (50.01%; 65.99%)	0.672
Observations	10,000	150	

Table 4: Baseline characteristics

according to DHS cluster number is not possible as 45 out of 629 clusters, used by the DHS for sampling, contain less than 5 observations, leading to potential convergence problems.

5.4 Baseline characteristics

Table 4 shows the baseline characteristics of the two samples. The difference of means was tested with a t-test while chi-squared tests were performed for proportions. The sample of HIV unexposed children (n = 10,000) and HIV exposed children (n = 150) differ significantly in terms of birth order, breastfeeding status and maternal age. The share of children born as the third or older child is significantly lower in HIV unexposed households (17.96%) than in HIV exposed ones (26%). Also mean maternal age is significantly lower in HIV unexposed households (29.45 years against 34.08 years). In terms of households-related factors, the mothers of HIV exposed children are more likely to be a single mother and the share of HIV exposed children living in urban households is significantly higher. The remaining

	HIV unexposed children		HIV exposed children		P-value
Stunting z-score	-1.36	(-1.39; - 1.32)	-1.68	(-1.95; -1.41)	**0.0257**
Stunting	29.73%	(19.07%; 40.39%)	28.93%	(27.59%; 30.26%)	0.880
Wasting z-score	- 0.01	(-0.05; 0.02)	0.30	(0.05; 0.55)	**0.0199**
Wasting	2.74%	(0%; 6.57%)	3.63%	(3.08%; 4.18%)	0.685
Underweight z-score	-0.79	(-0.82; -0.76)	-0.71	(-0.95; -0.47)	0.5236
Underweight	9.46%	(2.63%; 16.29%)	11.69%	(10.74%; 12.63%)	0.554
CIAF	32.43%	(21.51%; 43.35%)	32.61%	(31.24%; 33.99%)	0.974

Table 5: Share of children aged 0-59 months stunted, wasted, underweight by HIV exposure

characteristics do not differ significantly and are similar. However, it has to be noted that confidence intervals of HIV exposed children are by far larger than of HIV unexposed children due to the lower number of observations.

Also for the indicators of malnutrition, the differences in z-scores were assessed by carrying out independent t-tests, while chi squared tests were used to test the different proportions of children classified as stunted, wasted, underweight and CIAF. The analysis reveals that the mean stunting z-score of HIV exposed children (-1.68) is significantly lower than in HIV unexposed children (-1.36), indicating an on average higher risk of stunting in HIV exposed children. On the other side, HIV unexposed children have a significantly higher mean wasting z-score (0.30) than HIV unexposed children (- 0.01), but there is no significant difference in mean underweight z-scores. However, none of the mean estimated z-scores are more than two standard deviations below the WHO Child Growth Median (0), representing the threshold for determining malnutrition. Consistent with the high levels of malnutrition found for all children under the age of five in Section 4.3, mean z-scores of underweight and especially stunting are far below the WHO International Child Growth Medium.

Looking at the proportion of HIV exposed and unexposed children being classified as stunted, wasted or underweight, none of these differences are statistically significant. Also in terms of the share of children suffering from at least one form of malnutrition, the share of HIV exposed and unexposed children does not differ significantly.

Patterns detected in the simple mean tests might be affected by the socioeconomic status and other confounding factors that might have an effect on the undernutrition in HIV exposed children. A multivariate regression analysis is thus necessary to determine the individual effects of the socioeconomic environment and HIV exposure on child malnutrition.

6 Results

Stunting

Table 6 presents the results of the OLS regression in terms of stunting. The bivariate analysis (1) finds a negative, highly significant effect of HIV exposure on the stunting z-score of Tanzanian children under the age of five (p=*0.009*). Not controlling for any other factors apart from HIV exposure, the regression shows that HIV exposed children tend to be 0.32 standard deviations shorter than unexposed children. This highly significant association holds when controlling for child, maternal and socioeconomic factors. In fact, it becomes even stronger. Controlling for confounding factors, the estimations show that HIV-exposed children tend to have a stunting z-score that is 0.45 standard deviations below the one of HIV-unexposed children (p=*0.008*), putting these children at a higher risk of being stunted. Even though this regression does not estimate how much higher the risk is, this is already a remarkable effect given that the cutoff value is two standard deviations below the WHO Child Growth Standard. However, the characteristic of being HIV exposed alone is not enough to decrease the z-score of a perfectly healthy child from a favourable socioeconomic environment to be underneath the threshold of being stunted. Although the wealth index as a measure of the socioeconomic environment is highly significant (p=*0.000*), the estimate is only slightly above zero. Being from a household of higher socioeconomic status only marginally increases the height-for-age z-score. Also when using different measures for the socioeconomic environment (regressions 3-5), the effect of HIV exposure remains positive and highly significant. However, the extent of the effect of the socioeconomic environment differs according to the measure adopted. Using the DHS wealth score that is unadjusted

Table 6: OLS regression: Stunting

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
HIV exposure	-32.735***	-45.020***	-46.846***	-44.994***	-47.151***	-46.428***	-43.600***
	(11.653)	(15.721)	(16.296)	(15.676)	(16.398)	(16.453)	(15.826)
Child Age (months)		-2.909***	-2.939***	-2.908***	-2.942***	-2.927***	-2.890***
		(0.305)	(0.303)	(0.305)	(0.303)	(0.299)	(0.309)
Male		-12.286**	-12.158**	-12.275**	-12.373**	-12.174**	-11.952**
		(5.396)	(5.376)	(5.378)	(5.532)	(5.604)	(5.401)
Birthorder 6+		-17.605*	-22.405**	-17.451*	-23.177**	-25.652**	-16.959*
		(9.627)	(9.865)	(9.621)	(9.921)	(10.061)	(9.525)
Birthinterval $>$ 24 months		-0.972	-0.269	-0.953	-0.078	0.411	-0.661
		(6.370)	(6.442)	(6.365)	(6.493)	(6.496)	(6.371)
Ever breastfed		12.650	13.735	12.480	14.420	14.359	12.992
		(11.513)	(11.472)	(11.464)	(11.454)	(11.485)	(11.237)
Birthsize below average		-53.992***	-55.070***	-53.935***	-55.741***	-55.903***	-54.704***
		(9.815)	(10.210)	(9.820)	(10.250)	(10.306)	(9.840)
Twin/ multiple birth		-111.002***	-111.755***	-110.989***	-110.991***	-111.233***	-111.664***
		(17.380)	(17.529)	(17.313)	(17.932)	(18.382)	(17.392)
Maternal Age (years)		0.712**	0.965***	0.709**	0.996***	1.219***	0.757**
		(0.336)	(0.342)	(0.334)	(0.340)	(0.336)	(0.346)
Completed primary education		3.681	8.479	3.670	8.759	13.922*	
		(6.639)	(6.502)	(6.637)	(6.610)	(7.252)	
Completed secondary education							11.530
							(7.106)
Single mother		-12.021	-14.079*	-11.791	-14.741*	-14.292*	-12.111
		(7.940)	(7.988)	(7.938)	(7.972)	(8.017)	(8.030)
Urban residence		24.413***	24.709***	-0.771	16.059**	22.118***	22.312***
		(6.273)	(6.601)	(6.904)	(7.562)	(6.755)	(6.451)
Wealth score Rural/ Urban		0.000***					0.000***
		(0.000)					(0.000)
Wealth index Rural/ Urban			15.680**				
			(6.504)				
Wealth score combined				0.000***			
				(0.000)			
Wealth index combined					15.777*		
					(7.935)		
Employment past year						-4.921	
						(11.118)	
Employment x Seasonality						-4.488	
						(12.677)	
Constant	-135.495***	-109.180***	-130.160***	-100.756***	-129.497***	-126.625***	-111.337***
	(4.841)	(19.873)	(19.050)	(19.988)	(19.255)	(19.214)	(20.170)
Observations	4,509	2642	2642	2642	2642	2642	2642

Standard errors in parentheses
Data: DHS Tanzania 2022
Estimates have to be divided by 100 to get standard deviations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

for residence (4), results do not change and the effect is still marginal (*p=0.000*). When classifying households into being below or above the mean of the residence adjusted (3) (*p=0.022*) or unadjusted (5) (*p=0.056*) wealth score, significance decreases. With both controls, children in households considered to be above the mean wealth score tend to be 0.15 standard deviations longer than children from families below the mean. The difference in the size of effect might be due to the conceptualisation of the variables. While regression (2) and (4) use continuous variables for the wealth score, regressions (3) and (5) use dummy variables. As children are only divided into two groups, effect sizes are larger. When controlling for employment and seasonality of employment (6), the effect of HIV exposure on stunting z-scores does not change but income-related variables become insignificant (*p= 0.661* for employment and *p= 0.726* for seasonality). This indicates that it might not only be income but rather a combination of several socioeconomic factors as wealth, household possessions and sanitary facilities that matter for being at a higher or lower risk of being stunted. However, as this study is concerned with correlational evidence only, no causal inference can be made.

Consistent with the findings in Section 4.3.1, the study shows that older (*p=0.000*) and male (*p=0.030*) children born to younger mothers (*p=0.042*) as well as children living in rural areas (*p=0.001*) are at a higher risk of being stunted. Children being born as a twin or as part of a multiple birth (*p=0.000*) and born with a birth size below average (*p=0.000*) are at a substantially higher risk of being stunted compared to children being born as singletons and/ or with a birth weight above average. The length of the preceding birth interval, if a child was ever breastfed, the educational attainment of the mother and her marital status do not seem to matter greatly for the risk of being stunted.

Wasting

Also in terms of wasting, the OLS bivariate analysis (1) shows a significant, positive effect of HIV exposure on wasting z-scores. The wasting z-score of HIV exposed children tends to be 0.31 standard deviations higher than of HIV unexposed children (Table 7).

Table 7: OLS regression: Wasting

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
HIV exposure	31.198**	37.906**	38.401**	37.940**	38.568**	38.170**	39.323**
	(13.144)	(14.763)	(14.935)	(14.784)	(14.828)	(15.031)	(14.616)
Child Age (months)		-1.477***	-1.470***	-1.477***	-1.472***	-1.478***	-1.458***
		(0.288)	(0.290)	(0.289)	(0.289)	(0.287)	(0.286)
Male		-5.712	-5.730	-5.711	-5.724	-5.774	-5.863
		(4.414)	(4.381)	(4.416)	(4.350)	(4.396)	(4.472)
Birthorder 6+		-6.111	-4.792	-5.985	-5.399	-3.893	-7.637
		(8.220)	(8.129)	(8.244)	(8.122)	(8.435)	(8.324)
Birthinterval > 24 months		7.715	7.519	7.675	7.763	7.421	8.143
		(6.673)	(6.643)	(6.671)	(6.656)	(6.626)	(6.800)
Ever breastfed		-2.539	-2.852	-2.544	-2.937	-3.041	-1.667
		(11.514)	(11.612)	(11.497)	(11.713)	(11.492)	(11.490)
Birthsize below average		-39.469***	-39.201***	-39.450***	-38.915***	-38.907***	-39.675***
		(9.252)	(9.112)	(9.252)	(9.074)	(9.204)	(9.370)
Twin/ multiple birth		-7.464	-7.274	-7.464	-7.561	-7.540	-7.888
		(14.623)	(14.690)	(14.626)	(14.404)	(14.742)	(14.710)
Maternal Age (years)		-0.374	-0.442	-0.382	-0.399	-0.522	-0.441
		(0.421)	(0.415)	(0.421)	(0.417)	(0.447)	(0.432)
Completed primary education		15.933***	14.605**	15.726***	16.503***	13.196**	
		(5.545)	(5.344)	(5.512)	(5.096)	(5.870)	
Completed secondary education							-0.170
							(7.727)
Single mother		5.185	5.733	5.192	5.833	5.675	6.108
		(6.557)	(6.726)	(6.551)	(6.760)	(6.771)	(6.571)
Urban residence		5.237	5.201	11.336	10.097	5.928	7.516
		(6.473)	(6.510)	(9.431)	(7.558)	(6.579)	(6.868)
Wealth score Rural/ Urban		-0.000					-0.000
		(0.000)					(0.000)
Wealth index Rural/ Urban			-3.867				
			(6.746)				
Wealth score combined				-0.000			
				(0.000)			
Wealth index combined					-10.464		
					(8.056)		
Employment past year						1.550	
						(8.947)	
Employment x Seasonality						2.478	
						(8.526)	
Constant	-1.362	28.991	34.478*	27.402	34.371*	33.176*	42.050**
	(4.791)	(18.448)	(18.119)	(18.918)	(18.338)	(18.329)	(18.071)
Observations	4,533	2651	2651	2651	2651	2651	2651

Standard errors in parentheses
Data: DHS Tanzania 2022
Estimates have to be divided by 100 to get standard deviations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Controlling for confounding factors, HIV exposure remains to have highly significant effect on wasting (*p=0.015*). Even more, the effects appears stronger when controlling for potential confounding characteristics. Controlling for child, maternal and households characteristics, HIV exposed children tend to have a weight-for-age z-score that is 0.37 standard deviations above the z-score of unexposed children. Contrary to the risk of being stunted, the regression provides evidence that Tanzanian HIV exposed children under the age of five tend to be at a lower risk of being HIV exposed than their unexposed counterparts. This estimate is robust regardless of the measure adopted for the socioeconomic environment (regressions 3-5).

Interestingly, the effect of the socioeconomic environment is not significant for any of its measures included in the regression. Especially in terms of maternal employment in the past 12 months (*p=0.864*) as well as the seasonality of the employment (*p=0.773*), characteristics that have direct influence on the household budget and thus also on the ability to provide food, this effect is insignificant. However, this regression only controlled for maternal income but not possible income of other household members that could have compensated a potential loss of income.

Similar to the risk of stunting, older children are at a higher risk of being wasted (*p=0.000*), as well as children born with a birth size below average (*p= 0.000*). Children born to mothers that at least completed primary school tend to be at a higher risk of being wasted (*p=0.007*). However, this effect becomes insignificant once controlling for mothers that have at least completed secondary school. There is no significant effect of male gender (*p=0.205*), rural residence (*p=0.425*), which can also be observed in Section 4.3.2. Multiple births (*p=0.614*), birth order (*p= 0.463*), breastfeeding history (*p=0.827*), maternal age (0.463) and marital status (*p=0.435*) are not statistically significant.

Underweight

Regression results are presented in Table 8. Contrary to what was found in the two regressions presented above, HIV exposure does not have a significant effect on the risk of a Tanzanian child under the age of five being underweight. This result holds for both bivariate

Table 8: OLS regression: Underweight

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
HIV exposure	8.192	6.682	6.099	6.709	6.075	6.146	8.069
	(-78.962)	(14.348)	(14.442)	(14.332)	(14.362)	(14.303)	(14.322)
Child Age (months)		-2.111***	-2.120***	-2.110***	-2.122***	-2.120***	-2.091***
		(0.255)	(0.253)	(0.255)	(0.254)	(0.252)	(0.256)
Male		-9.974**	-9.899**	-9.969**	-10.011**	-9.989**	-10.054**
		(4.525)	(4.516)	(4.515)	(4.584)	(4.581)	(4.535)
Birthorder 6+		-14.510*	-15.784**	-14.379*	-16.689**	-16.995**	-15.640**
		(7.422)	(7.680)	(7.450)	(7.664)	(8.035)	(7.311)
Birthinterval > 24 months		7.058	7.180	7.048	7.480	7.519	7.419
		(6.251)	(6.145)	(6.253)	(6.142)	(6.150)	(6.312)
Ever breastfed		7.712	7.982	7.637	8.338	8.345	8.439
		(11.051)	(11.051)	(11.031)	(11.122)	(11.150)	(11.047)
Birthsize below average		-70.065***	-70.384***	-70.033***	-70.533***	-70.568***	-70.391***
		(8.842)	(8.916)	(8.843)	(8.887)	(8.998)	(8.661)
Twin/ multiple birth		-81.924***	-82.169***	-81.919***	-81.958***	-81.936***	-82.398***
		(17.262)	(17.288)	(17.261)	(17.287)	(17.338)	(17.301)
Maternal Age (years)		-0.016	0.049	-0.021	0.099	0.128	-0.060
		(0.322)	(0.332)	(0.323)	(0.322)	(0.350)	(0.332)
Completed primary education		13.061***	14.098***	12.951***	15.657***	16.282***	
		(4.411)	(4.426)	(4.409)	(4.004)	(4.641)	
Completed secondary education							1.757
							(5.427)
Single mother		-1.568	-2.140	-1.462	-2.466	-2.407	-0.842
		(6.498)	(6.406)	(6.506)	(6.391)	(6.454)	(6.536)
Urban residence		16.576***	16.874***	8.228	15.201**	15.921***	17.995***
		(5.412)	(5.342)	(7.592)	(5.823)	(5.307)	(5.530)
Wealth score Rural/ Urban		0.000					0.000
		(0.000)					(0.000)
Wealth index Rural/ Urban			6.617				
			(5.491)				
Wealth score combined				0.000			
				(0.000)			
Wealth index combined					1.882		
					(6.219)		
Employment past year						-0.122	
						(7.423)	
Employment x Seasonality						-1.151	
						(8.936)	
Constant	-78.962***	-48.874***	-55.686***	-45.862***	-55.406***	-55.073***	-39.033**
	(3.098)	(14.988)	(14.674)	(15.451)	(14.793)	(14.853)	(16.003)
Observations	4,532	2657	2657	2657	2657	2657	2657

Standard errors in parentheses
Data: DHS Tanzania 2022
Estimates have to be divided by 100 to get standard deviations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

analysis (1) (p= *0.476*) as well as when controlling for potential confounding factors (p= *0.47*). As underweight is a composite indicator of stunting and wasting, this might be due to the opposite effects observed on stunting and wasting. The significant negative effect on the risk of being stunted and the significant positive effect on the risk of being wasted might have compensated each other.

Also a less favourable socioeconomic environment does not put children at a significantly higher risk of being underweight. The analysis does not find any significant effect, regardless of the measure adopted. This study finds older children (p=*0.000*), males (p=*0.035*), children born at a higher birth order (p= *0.060*) and living in rural areas (p=*0.005*) to be more likely to be underweight than their counterparts. Additionally, children born with a birth size below average (p=*0.000*), as part of a multiple birth (p=*0.000*) are at a higher risk of being underweight. These findings, with the exception of birth order, can also be observed in Section 4.3.3. The study shows that children whose mothers have at least completed primary education, are less likely to be underweight (p=*0.006*). However, the significance of this association vanishes once controlling for completion of secondary education (p=*0.748*). Breastfeeding history (0.451), the preceding birth interval (p=*0.249*) as well as maternal marital status (p=*0.898*) do not have a significant effect on the risk of being underweight.

7 Discussion

HIV exposure is shown to have a significant effect on stunting and wasting z-scores. This holds for both bivariate analysis and when controlling for child and maternal characteristics as well as the socioeconomic environment. Controlling for confounding factors, both effects seem to be even stronger. The effect of HIV exposure on underweight is never significant. This study can thus only partly confirm the findings of Magadi (2011-a) who finds HIV exposure to significantly increase the risk of being stunted, wasted and underweight by 28%, 26% and 26% respectively. However, as mentioned in an earlier section, Magadi (2011-a)'s study does not differentiate between HIV negative and HIV positive children and her estimates might thus be biased. The socioeconomic environment is only found to be significant in terms of the risk of being stunted and does not change the directions of the significant effects mentioned above. Children from wealthier families are less likely to be stunted, this effect becomes stronger if diving the sample into households belonging to the upper or lower half in terms of household wealth. However, the effect of household wealth is estimated to be lower than the effect of HIV exposure.

Stunting is a measure of chronic malnutrition that develops over time and has thus more structural and deeper causes than temporary food insufficiencies. The presence of a significant, negative association between HIV exposure and stunting risk while controlling for the socioeconomic environment and other possible confounding factors, indicates that HIV exposure might affect stunting through medical channels as in utero growth or an elevated infection risk. However, as this thesis is concerned with correlational analysis only and the DHS does not provide sufficient data to control for medical factors, possible channels can only be hypothesized. As already mentioned in the definition of stunting, the WHO (2014b) lists socioeconomic reasons as one possible source of stunting. Children in households that do not have enough resources for providing sufficient food over a longer period of time are not surprisingly at a higher risk of being stunted.

Wasting indicates acute undernutrition and the sources of wasting are thus of more temporary nature (WHO, 2014b). Consistent with this definition, socioeconomic factors are found to be insignificant. Temporary adverse income shocks through job loss and/ or seasonality might however have a negative effect on wasting risk if not compensated otherwise. Surprisingly, the regression does not show a significant effect of maternal employment within 12 months prior to the DHS survey or seasonality on the wasting z-score. However, this might have two possible explanations based on the findings. As the regression controls for employment and its seasonality of mothers only, variations in employment might have been compensated by other household members or partners living in the same household. Additionally, the effect might have been captured by education. Higher educated individuals tend to have a higher income and the effect might thus have been captured by the education variable. The effect of education becomes insignificant when controlling for mothers that have at least completed secondary education. This might be due to the fact that there is only a low share of mothers having completed secondary education (27.62%).

The regression shows that HIV exposed children are at a lower risk of being wasted. As shown in Figure 12, wasting levels were highest in children aged zero and one in 2022. This finding might be due to the breastfeeding recommendations for HIV positive mothers. The WHO (n.d.-e) recommends HIV positive women to breastfeed throughout the child's first year of life at least and even longer. This might reduce the risk of being wasted as the child is receiving nutrients through the breast milk. Although breastfeeding is found to be insignificant, this variable does not capture the length of breastfeeding but only if a child was ever breastfed. Additionally, in Tanzania, HIV exposed children and their mothers are followed up medically throughout the first two years of life (Mnzava et al., 2018). Wasting might thus be detected earlier and interventions can be started in due time. Both HIV exposure and the socioeconomic environment are found to be insignificant in terms of its effect on the underweight z-score.

This study finds older children to be at a higher risk of malnutrition regardless of the indicator, with the effect being stronger on stunting and underweight levels. As stunting requires some time for malnutrition to chronify, the youngest children in the sample might not be old enough to have endured the adverse effects of stunting for it to chronify. Thus, the risk of stunting might be higher for older children compared to the younger ones. As wasting is an indicator of temporary malnutrition, the difference in risk might be lower for younger children in terms of stunting than it is for wasting.

Similar to McDonald et al. (2012), this study finds being male, and born with a birthsize below average to be risk factors for stunting in Tanzanian children. As this study provides correlational evidence only, the odds ratios were not estimated. McDonald et al. (2012)

estimates the risk of stunting to be 28% higher for males, 2.5 times higher for children born underweight, and up to 0.29 times higher for children from wealthier households. Also Khamis et al. (2020) have found males to be at a higher risk of undernutrition in Tanzania, similar to studies from different Sub-Saharan countries (Magadi, 2011-a). However, scientific explanations of this phenomena are still lacking (Khamis, Mwanri, Kreppel, Kwesigabo, et al., 2020).

Contrary to Khamis et al. (2020), Magadi (2011-a) and McDonald et al. (2012), this analysis did not find educational attainment of the mother to be significantly associated with the z-score of stunting in the Tanzanian context. However, the presence of a slightly significant effect when controlling for income only instead of the socioeconomic environment (Table 6, (5)), shows that education might also be captured in the DHS wealth index variables.

Apart from HIV exposure and an older age, this study finds higher maternal education and a birth size below average to be positively associated with wasting. Not surprisingly, maternal education is highly significant in terms of wasting. Children born to mothers without completed primary education are at a significantly higher risk of being wasted. Higher educated women have, on average, higher incomes due to superior work opportunities and tend to be more acceptable to nutritional programs transmitted by media (Khamis et al., 2020). Being born with a birth size below average has also been found to be a predictor of wasting in Tanzanian children with children born with a birth size to be at a 49% higher risk of being underweight (McDonald et al., 2012).

Underweight, being a composite indicator, is difficult to interpret WHO (n.d.), and risk factors associated with underweight might thus be as well. However, risk factors for being underweight are consistent with the ones found for stunting and partly for wasting. Risk factors found in the regressions regarding underweight might thus be based on the regressions regarding stunting and wasting. Consistent with Khamis et al. (2020), education and male sex are found to be significantly associated with underweight in Tanzanian children. Children born to women that have not completed primary school as well as males, are at a higher risk of being underweight. McDonald et al. (2012) estimates this risk to be 30% and 40% higher respectively in Tanzanian chlidren. Children with a birth size above average are less likely to be underweight. In fact, Muhangi et al. (2013) estimates the risk to be 3 times higher.

8 Conclusion

Overall, both HIV/ AIDS and child malnutrition remain to be challenges of major health concern in Tanzania despite substantial progress in the past two decades. Especially older females of reproductive age are at the highest risk of becoming HIV infected with the risk varying by region. HIV testing rates are low in the whole country, with coverage being significantly higher for women, older individuals and urban residents. The first factor might be due to high testing rates during pregnancy, which are at a level of over 90%. However, testing rates need to be increased in the near future and the country is far from reaching the goal of achieving a 95% testing rate by 2025 set by the UN. Especially males and younger age groups show most potential for increasing testing rates and campaigns should pay special attention to these groups. There is still progress needed to be achieved in order to achieve SDG Target 3.3 of reducing HIV incidence to 0.25% by 2030. While male HIV incidence is almost complying with the UN goals set by 2030 already now (0.27%), female incidence (0.64%) is still on a very high level. Almost all adults diagnosed with HIV are on ARTs, meeting the internationally set goal of having 95% of all HIV positive individuals accessing ARTs. This also promises a reduction of HIV incidence in the near future and prevalence in the long-term future, making a step towards ending the HIV epidemic.

Child malnutrition rates in the country are high, with one third of children suffering from at least one anthropometric growth failure. Looking at stunting (29.66%), wasting (3.22%) and underweight (11.63%) separately, child malnutrition remains high despite the progress of the past years. Stunting and underweight prevalence tends to be highest in males over the age of one living in rural areas. While stunting rates are highest in the regions of Iringa and Rukwa, they are highest in the Northeastern and Southwestern regions for underweight. Younger males are at a higher risk of being wasted, with no significant differences according to region and residence. Regarding the targets set in SDG 2.2 in order to end malnutrition, Tanzania is on track of achieving a wasting rate of under 5% by 2025. However, urgent measures are needed in order to reduce stunting levels by 40% compared to 2010 estimates. Between 2010 and 2022, stunting levels have been reduced by 29.7%, calling for immediate action in order to reach the internationally agreed UN targets.

A simple mean and proportion comparison reveals that stunting and wasting z-scores of HIV exposed and unexposed children differ significantly from each other. While they tend to be higher for unexposed children in terms of stunting, they are more likely to be higher for exposed children in terms of wasting. No significant differences could be found in terms of underweight z-score as well as the proportion of children being classified as stunted, wasted, underweight or having at least one of these forms of undernutrition.

In order to control for confounding factors, a multivariate OLS regression was carried out. Carrying out a multivariate analysis, the effect of HIV exposure on stunting z-scores still remains negative and highly significant. The socioeconomic environment rather than income alone is highly significant, but affects stunting z-scores of children to a lower extend than HIV exposure. In terms of wasting, HIV exposed children tend to be at a lower risk of being wasted, with the socioeconomic environment only having an insignificant effect. For both stunting and wasting, the association between HIV exposure and stunting z-score as well as wasting z-score appears to be stronger when controlling for child, maternal and socioeconomic characteristics rather than when performing a bivariate regression. No significant association was found between HIV exposure or the socioeconomic environment and underweight z-scores. Similar to what was revealed in the descriptive study, older males living in rural areas tend to be at a higher risk of being stunted and underweight, so are children with a birth size below average and part of a multiple birth. Risk factors of becoming wasted include older age, being born with a birth size below average and being born to a mother with lower educational attainment.

The above presented findings highlight the importance of adopting multisectoral approaches to decrease the number of children under the age of five suffering from undernutrition. By scaling up HIV testing rates as well ART access, mother-to-child transmissions can be prevented and the risk of horizontal transmissions decreased so that less children will be HIV-infected in the future. Especially for children, testing campaigns should be implemented in order to detect HIV infections as early as possible. Early interventions are needed to prevent growth failures in children. As wasting in children can still be mitigated by giving appropriate nutrition, nutritional screening should be offered to all children at a higher risk of wasting. For severe cases, nutritional counselling should be offered free of charge and mothers should be educated on nutritional practices. In order to reach the SDG target 2.2 of reducing stunting rates by 40% compared to 2010, campaigns should be targeted at children with lower socioeconomic status as well as HIV exposed children.

The study presented in this paper is not free of limitations. One major limitation is that the HIV status of children is not determined in the DHS sample and HIV status of children can only be proxied. Additionally, even though based on population-based data and thus not on a specific setting, there is a small sample of HIV exposed children probably due to the moderate HIV rates in Tanzania. However, significant associations are found despite the small sample size. Another limitation of the regressions analysis is a possible survivor bias as only children that are alive at the point of survey could be measured for the purpose of the DHS. However, unless mortality patterns differ largely between birth cohorts, comparisons across sub-groups as well as time should only be affected marginally Magadi (2011-a). Lastly, the DHS does not provide data on the viral load of the mother. Lyatuu et al. (2023) showed that vertical transmission rates increase with disease advancement and thus also with the viral load in the blood.

Future studies should focus on malnutrition in HIV exposed households by not only determining HIV exposure by maternal HIV status but also by HIV status of the father or other household members. For this, additional information not yet provided by the DHS is needed to carry out a meaningful analysis that can help to inform political interventions to decrease malnutrition rates in HIV exposed children. Using data from the next (future) DHS cohort for Tanzania would also allow to follow up the trends and patterns analysed in this paper as well as detecting time trends in malnutrition of HIV exposed children.

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