




Leaving No One Behind: Multidimensional Child Poverty in Botswana

Khaufelo Raymond Lekobane^{1,2}  · Keetie Roelen¹

Accepted: 30 April 2020 / Published online: 18 May 2020
© The Author(s) 2020

Abstract

Child poverty measurement is vital for informing policies and for improving children's lives. Nevertheless, efforts to measure (child) poverty remain dominated mainly by monetary approaches, and many countries fail to monitor multidimensional child poverty. Using the 2015/2016 Botswana multi-topic household survey, this study developed a child-centred, individual-level and composite measure that offers nationally relevant and context-specific insights into the magnitude and depth of multidimensional child poverty in Botswana. In particular, it did so through the lens of Leave No One Behind (LNOB) by zooming in on demographic, economic and geographical characteristics that may be associated with greater vulnerability or marginalisation using both descriptive and regression analysis. Results point towards a relatively high incidence and depth of multidimensional child poverty in Botswana. Results show that disabled children, orphans, children living in larger families, families headed by unmarried couples and living in rural areas are more likely to be multidimensionally poor.

Keywords Child poverty · Multidimensional poverty · Leave no one behind · Botswana

1 Introduction

Child poverty measurement is vital for informing policies and for improving children's lives. Several reasons have been put forward in the literature outlining the need to analyse and investigate child poverty. First, children are dependent on others in their

✉ Khaufelo Raymond Lekobane
khaufelo@gmail.com; R.Lekobane@ids.ac.uk

Keetie Roelen
K.Roelen@ids.ac.uk

¹ Institute of Development Studies, University of Sussex, Brighton, UK

² Botswana Institute for Development Policy Analysis (BIDPA), Gaborone, Botswana

direct environment for the provision of basic needs that are essential for their development (Trani and Cannings 2013). Second, children experience poverty and are affected by it differently compared to adults (Leu et al. 2016). Third, a child-centred approach to poverty measurement is vital for ensuring that commitment to children's rights is monitored (Leu et al. 2016).

Following widespread acknowledgement of these arguments, there is now a robust literature on multidimensional child poverty measurement. The pioneering cross-country study by Gordon et al. (2003) gave rise to country-level studies (e.g. Amarante et al. 2010; Roche 2013; Roelen et al. 2010) in the early 2000s and ultimately paved the way for UNICEF's Multiple Overlapping Deprivation Analysis (MODA) (de Neubourg et al. 2012). More recently, the increasingly adopted global measure of multidimensional poverty – the Multidimensional Poverty Index (MPI) – has been disaggregated and adjusted to analyse the situation through a child-focused lens (Alkire et al. 2017, 2019). At present, much debate regarding multidimensional child poverty measures focuses on the comparative merits of the MODA and MPI approaches (e.g. Hjelm et al. 2016; Vaz et al. 2019). MODA places the child at the centre of analysis by including individual-level indicators and incorporating the child as a unit of analysis. MPI allows for the calculation of a composite index that offers insights into the scale and magnitude of the issue of multidimensional child poverty.

Notwithstanding these debates and widespread efforts to measure poverty from a multidimensional perspective, monetary measures remain dominant, and child poverty receives relatively limited attention (Global Coalition to End Child Poverty 2019). Botswana is a case in point. Poverty in Botswana has been almost exclusively measured using the traditional monetary approach, and little attention has been paid to child poverty in specific. However, in alignment with the Sustainable Development Goals (SDGs), Botswana's new Poverty Eradication Policy and Strategy (BPEPS), includes recommendations to reduce the intergenerational transmission of poverty through the eradication of severe multidimensional child poverty (Republic of Botswana [RoB] 2018).¹ This commitment is further underpinned by the principle of LNOB, thereby highlighting the need to include all children in efforts to reduce poverty. The commitment to the eradication of multidimensional child poverty in conjunction with the LNOB principle calls for a comprehensive country- and context-specific measure of multidimensional child poverty for Botswana.

The objective of this study is twofold. First, it aims to extend the current field of child poverty measurement by building on two dominant approaches, namely MODA and MPI. It builds on the comparative advantages of these approaches by developing a child-centred, individual-level and composite measure that offers nationally relevant and context-specific insights into magnitude and depth of multidimensional child poverty in Botswana. Second, and relatedly, it seeks to provide empirical insights into the state of multidimensional child poverty in Botswana through the lens of LNOB. Findings will serve as a baseline study in Botswana to track progress towards SDG 1 and national development plans regarding eradication of multidimensional child poverty and LNOB.

¹ The BPEPS defines 'severe multidimensional child poverty' as deprivation in at least 50% of relevant dimensions under consideration.

The remainder of the paper is organised as follows: Section 2 offers an overview of multidimensional child poverty measurement, including background on the situation of children and poverty in Botswana. Section 3 presents data and methodology. Section 4 provides results, and Section 5 presents conclusions and policy implications.

2 Multidimensional Child Poverty Measurement

Gordon et al. (2003) pioneered the first global study on child poverty to compare multidimensional child poverty across developing countries. The approach is also referred to as the Bristol approach. Since then, the importance of measuring child poverty from a multidimensional perspective has been recognised (e.g., Roelen and Gassmann 2008; Roelen et al. 2009, 2010). The global significance of child poverty has also been recognised in the SDGs. Specifically, SDG target 1.2 calls for “reducing at least half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions” by 2030 (UN 2015). This target presents a significant step forward in the fight against child poverty in three ways: firstly, it explicitly recognises children; secondly, it acknowledges the multidimensional nature of poverty; and thirdly, it highlights the importance of national definitions.

Child-focused approaches are, therefore required to adequately analyse and investigate the issue of child poverty (Roelen 2010). Several approaches to measuring multidimensional child poverty have been employed in the empirical literature. Dominant approaches include the MPI (Alkire and Foster 2011) and MODA (de Neubourg et al. 2012). The MPI is theoretically premised on the capability approach and is methodologically grounded in the Alkire-Foster (AF) approach (Alkire and Foster 2011). The AF approach is flexible as it allows for the inclusion of different dimensions, indicators, cut-offs and dimensional weights that reflect the relative importance of each dimension (Alkire et al. 2015) and reflects deprivations into a single measure (Maasoumi and Yalowitzky 2013). The global MPI represents an application of the AF approach using three dimensions and ten indicators, adopting equal weighting at dimension level and using a proportion of weighted deprivations as the cut-off for being multidimensionally poor (Alkire and Jahan 2018). Crucially, the indicators within the global MPI are all household-level indicators. Estimates of multidimensional child poverty are based on a simple decomposition of overall poverty estimates for children (see Alkire et al. 2017). Many studies of multidimensional child poverty are methodologically premised on the AF approach (e.g., Roche 2013; Trani and Cannings 2013; Roelen 2010).

The MODA approach was developed by UNICEF (de Neubourg et al. 2012) to facilitate the analysis of inequities and to provide instruments to identify deprived children and is rooted in the rights-based framework of the Convention on the Rights of the Child (CRC) (Hjelm et al. 2016). The approach builds on the Bristol and AF approaches (Hjelm et al. 2016; de Neubourg et al. 2012) as it combines both household- and individual-level indicators and considers the interaction and depth of deprivations across indicators and dimensions. Notably, the MODA approach does not advocate for the construction of a composite index. Instead, MODA presents poverty figures using all possible cut-offs based on the number of

dimensions across specific age categories. Its primary focus is more on overlap analysis than aggregating into a composite index. This approach has been implemented to study multidimensional child poverty across countries (de Milliano and Plavgo 2014; Chzhen et al. 2016) and within countries (e.g. de Neubourg et al. 2015; Chzhen and Ferrone 2017).

2.1 Children and Poverty in Botswana

Botswana is an upper-middle-income country that has witnessed rapid economic growth for most of its post-independence period since 1966 (Seleka and Lekobane 2017). Economic growth went hand-in-hand with declining poverty rates. Monetary poverty rates, based on national poverty lines, reduced from 59% in 1985/1986 to 16.3% in 2015/2016 (SB 2016, 2018).² Impressive as they are, these figures only paint a partial picture of the poverty situation in the country. With respect to children, poverty incidence is higher than it is for adults. According to Statistics Botswana, child poverty stood at 20.1% compared to 13.8% for adults (SB 2018). However, these monetary figures do not depict the multifaceted deprivation suffered by children.

Other indicators suggest that many of Botswana's children experience deprivation in one or more areas of their lives. Although infant and child mortality rates have dropped considerably in the last four decades (SB 2016), HIV/AIDS infection rates continue to increase over time (SB 2014). Similarly, malnutrition and maternal mortality rates remain at high levels. Chronic malnutrition (stunting) and wasting stood at 30% and 11.6% in 2013, while the maternal mortality rate was 147/100,000 live births in 2012 (SB 2016). With respect to education, Botswana's enrolment rates have been consistently below those of other upper-middle-income countries, such as Algeria, Mauritius, Namibia and South Africa (World Bank 2015).

As noted above, Botswana has made strong commitments to eradicating child poverty, including multidimensional forms of child poverty. In line with the SDGs, Botswana developmental initiatives, such the National Development Plan 11, Vision 2036 and the BPEPS, articulate the need to eradicate multidimensional poverty, including multidimensional child poverty (MFED 2016; RoB 2016, 2018). Despite these commitments, limited efforts have so far been undertaken to gain insight into issues of multidimensional (child) poverty. In 2015, UNICEF published a study of multidimensional child poverty based on the MODA approach (de Neubourg et al. 2015). The study offered critical empirical insights and confirmed the notion that deprivation is widespread among children in Botswana. However, it did not provide a composite measure of multidimensional poverty for all children in the country. In this study, in addition to providing detailed analysis at indicator level, we provide an aggregate estimate of the proportion of multidimensionally poor children at the national level and across demographic, geographical and economic variables in line with LNOB.

² Monetary poverty in Botswana is measured using consumption expenditure and is based on the poverty datum line (PDL) method. If a household's total consumption falls below the corresponding PDL then the household and every individual in that household is considered poor (SB 2018).

3 Data Sources and Methods

3.1 Data Sources

Our analysis utilises the 2015/2016 Botswana multi-topic household survey (hereafter 2015/2016 BMTHS) collected by Statistics Botswana (SB). This survey is a cross-sectional and nationally representative survey, allowing for disaggregation at the district level. The survey aims to provide a comprehensive set of indicators designed to produce multidimensional welfare indicators at both household- and individual-level to allow for enriched and in-depth analyses. According to SB (2018), the 2015/2016 BMTHS results will be used for policy formulation, NDPs, Vision 2036 and the SDGs. The 2015/2016 BMTHS will also serve as a baseline to track the progress of BPEPS and poverty eradication programmes implemented by various stakeholders (SB 2018).

The original dataset contains information from a sample of 24,720 individuals from 7060 households surveyed in 2015/2016. The estimated population when using sample weights is 2,073,675 individuals and an estimated 589,909 households (SB 2018). Our analysis is based on a sample of 9718 children aged 0–17 years from a sample of 3770 households. The estimated number of children is 817,843 from a total of 319,705 households, meaning that 54.2% of households had at least one child (Table 1).

3.2 Methods

This study combines conceptual and methodological principles from across the MODA and MPI approaches. Following the MODA approach, we seek to include as many child-level indicators as possible to create an individual-level measure and to give full consideration to overlapping deprivation analysis. Following the MPI approach, we build a composite measure that allows for estimating the incidence and depth of multidimensional poverty among children in Botswana. In line with the principle of LNOB, we also ensure that the measure is decomposable for different groups of children, particularly those that may be deemed vulnerable or marginalised.

In keeping with these principles, we adopt the AF approach for identification and aggregation. Identification is a two-step cut-off process (Alkire and Foster 2011). First, at indicator level, a child is considered deprived if their achievement is below a defined cut-off. Second, at aggregate level, the poverty cut-off represents the number of weighted indicators that a child must be deprived on in order to be considered multidimensionally poor (Alkire and Santos 2014). Aggregation is also a two-step process. First, a simple headcount ratio can be calculated that captures the incidence of

Table 1 Sample and population distributions 2015/2016

	Children (0–17)		All individuals	
	Sample	Population	Sample	Population
Households	3770	319,705	7060	589,909
Individuals	9718	817,843	24,720	2,073,675

Source: Authors' estimates based on the 2015/2016 BMTHS data

multidimensional poverty among a given population of children. In keeping with the global MPI (Alkire and Santos 2014), we use a poverty cut-off of 33.3% of weighted indicators. Second, the adjusted headcount ratio offers a measure of the intensity of multidimensional poverty by multiplying the average number of weighted deprivations with the simple headcount ratio. These measures satisfy the axioms of population subgroup decomposability and dimension breakdown (Chen et al. 2019), which is useful for policymakers when developing interventions and targeted policies (Alkire and Apablaza 2016). In line with the MPI, we adopt equal weighting scheme at the dimension level.

To check for robustness of our results, we compute poverty headcount ratios (H), intensity (A) and adjusted headcount ratio (M_0) considering three different poverty cut-offs (k values). We limit the values of k to a range of 25–40% to conduct restricted tests of dominance (see Alkire and Santos 2014). We then calculate multidimensional poverty measures across age, gender and geography to check if the results are stable. We find that in general H , A and M_0 across age, gender and geographical variables remain stable and consistent. For example, the ordering of districts does not change with Ngamiland West and Kweneng West ranking one and two (respectively) across poverty cut-offs (see Annex – Table 9).

3.3 Dimensions and Indicators

The choice of dimensions and indicators is informed by the capability approach in conjunction with the consensus approach (Alkire 2002). The capability approach directs us to look at vital functionings for children. Documents outlining Botswana's policy commitments and development priorities such as Vision 2036, NDP 11, BPEPS and the SDGs ensures that the measure is contextually relevant. The final choice of dimensions and indicators was restricted by data availability.

We include 23 indicators in seven dimensions: (i) *Assets*, (ii) *Housing and living condition*, (iii) *Water and sanitation*, (iv) *Food security*, (v) *Health*, (vi) *Education*, and (vii) *Security*. The selected dimensions cover most of the indicators and dimensions of the global MPI (Alkire and Santos 2014) and the dimensions proposed in MODA child poverty study for Botswana (de Neubourg et al. 2015). Table 2 presents the proposed dimensions, deprivation indicators, as well as the deprivation cut-offs. It also indicates the age brackets for which these indicators hold and whether the indicators were included in the 2015 MODA study. Below we provide a brief description of each dimension and the corresponding deprivation indicators.

Asset dimension includes indicators referring to possession of household assets that serve as a proxy for household living standards. This dimension comprises four deprivation indicators: information, durable goods, transport and housing tenure. Household durable assets are integral to the functioning and attainment of people's well-being, including children (Lerman and McKernan 2008). Lack of transport can impact negatively on children's access to health or education in cases where the facilities are far (Allendorf 2007). Housing tenure security is considered a right to adequate housing (Espinoza-Delgado and Klasen 2018). In the capability approach, homeownership is vital because it indicates a crucial functioning of "security or protection" (Doyal and Gough 1991).

Table 2 List of proposed dimensions and deprivation indicators

Dimension	Indicator ^a	Indicator definition	Deprivation cut-off (A child is deprived if ...)	Level	Age Group	MODA ^b
1. Asset	Information	Captures lack of access to information and communication by household members	He/she resides in a household which does not own at least one of the following: TV, radio, PC/laptop, telephone (landline), mobile	HH	0–17	N
	Durable goods	Captures lack of durable assets used within the house	He/she resides in a household which does not own at least two of the following: refrigerator, washing machine, electric/gas stove, microwave, air conditioner, wheelbarrow, sewing machine, grinding machine	HH	0–17	N
	Transport	Captures lack of ownership of automobiles (van/bakkie/truck or car)	He/she resides in a household which does not own any automobile including van/bakkie/truck, car, tractor, donkey cart, motorcycle, bicycle	HH	0–17	N
	Land tenure	Captures land ownership or possession of land and housing in which the housing unit is built	He/she resides in a household which does not own the land in which the housing unit is built	HH	0–17	N
2. Housing	Overcrowding	Captures the shortage of living space based on the number of rooms and persons in the household	He/she resides in a household with more than three people per sleeping room (excluding the kitchen, bathroom and garage)	HH	0–17	Y
	Cooking fuel	Captures the source of fuel for cooking used by households	He/she resides in a household which uses the following source of fuel: Biogas, wood, paraffin, cow-dung, coal, charcoal, and crop waste OR has no source of cooking fuel at all	HH	0–17	Y
	Floor material	Assesses the quality of the main material of the floor	He/she resides in a housing unit with the main material of floor made of the following: mud, mud dung, brick/stones, none or any other material apart from cement, floor tiles, or wood	HH	0–17	N
	Roof material	Assesses the quality of the main material of the roof	He/she resides in a housing unit with the main material of the roof is made of the following: thatch/straw, asbestos or any other material apart from slate, roof tiles, corrugated iron/zinc/tin, concrete	HH	0–17	N
	Wall material	Assesses the quality of the main material of the outside wall	He/she resides in a housing unit with the main material of the outside wall is made of the following: mud bricks/blocks, mud and poles/ cow	HH	0–17	N

Table 2 (continued)

Dimension	Indicator ^a	Indicator definition	Deprivation cut-off (A child is deprived if ...)	Level	Age Group	MODA ^b
3. Water & sanitation	Electricity	Assess household connectivity to the national grid	He/she resides in a household which is not connected to the BPC grid	HH	0–17	N
	Water supply	Assesses lack of access to a safe drinking water source	He/she resides in a household which uses unimproved water source: bowser/tanker, well, borehole, river/stream, dam/pan, rainwater, spring water, OR if it takes at least 30 min to fetch water from a communal tap	HH	0–17	Y
	Toilet facility	Measures lack of access to basic and safe sanitation facility in the household	He/she resides in a household which uses an unimproved toilet facility: pit latrine, communal flush toilet, communal VIP, communal pit latrine, communal neighbours' toilet OR has no toilet facility at all	HH	0–17	Y
4. Food security	Food insecurity access (HFIAP)	Assesses household's lack of access to sufficient quantity and quality food	He/she resides in a household which is categorised as moderately food insecure or severely food insecure based on HFIAP measure	HH	0–17	N
	Weight-for-age (WAZ)	Assesses children's nutrition status	He/she is a child who is malnourished. That is, if his/her z-score of weight-for-age is below minus two standard deviation from the median of the reference population	IND	0–4	Y
	Height-for-height (HAZ)	Assesses children's chronic nutrition status (stunting)	He/she is a child who is stunted. That is, if his/her z-score of height-for-age is below minus two standard deviation from the median of the reference population	IND	0–4	N
5. Health	Weight-for-height (WHZ)	Assesses children's nutrition status in terms of wasting	He/she is a child who is wasted. That is, if his/her z-score of weight-for-height is below minus two standard deviation from the median of the reference population	IND	0–4	N
	Body Mass Index (BMI)	Assesses children's nutrition status based on BMI	He/she is a child aged between 5 and 17 with a BMI z-score below minus two standard deviation from the median of the reference population	IND	5–17	Y
	Health facility	Assesses the perceived quality of the nearest health facility	The perceived quality of nearest health facility he/she uses is poor and has the following problems: the facility is too far, the facility is not clean or	HH	0–17	Y

Table 2 (continued)

Dimension	Indicator ^a	Indicator definition	Deprivation cut-off (A child is deprived if ...)	Level	Age Group	MODA ^b
6. Education	Chronic illness	Assess individuals' health status	in poor condition, few trained professional staff, staff frequently absent, lack of drugs, does not offer all services, limited opening hours	IND	0–17	N
	Enrolment	Quantifies the enrolment of individuals in the education system	He/she has a long-term chronic illness that prevents them from working, being active or going to school	IND	5–17	Y
	Literacy	Measures the ability of an individual to read and write	He/she is a child aged 5–17 and is currently not enrolled in school	IND	15–17	Y
7. Security	Safety	Assess the perceived safety of household from crime and violence	He/she is aged between 15 and 17 years and above and he/she can't read and write	HH	0–17	N
	Crime	Ascertains whether the member of the household has been a victim of violence or crime in the past 12 months	He/she resides in a household which has at least one member who has been a victim of violence or crime in the past 12 months	HH	0–17	N

Source: Developed by authors

^a HH stands for household, IND stands for individual. Level means the identification level

^b Y means indicator is included in the MODA study and N means the indicator is not in the MODA study. In MODA toilet facility indicator exclude children aged 0–4 years. With respect to nutrition, only weight-for-age indicator was included (weight-for-height and height-for-age were not included). For education indicators, school enrolment indicator was framed as 'child of 6–11 years is not attending school, if school is open and child is sick; Or not attending school or training of any type for child 12–17 years if junior school or training of any type was not completed by age 15' (de Neubourg et al. 2015)

Housing and living condition dimension aims to capture deprivations related to the quality of housing. Children have the right to basic shelter that will enable them to live a dignified life (UNHROHC 1989). Six deprivation indicators are considered for this dimension: overcrowding, cooking fuel, electricity, floor material, roof material and wall material. These indicators are closely associated with child health (UN-HABITAT 2009).

Water and sanitation dimension includes two deprivation indicators: access to safe drinking water and toilet facility. Contaminated water is a huge cause of diarrhoea-related diseases, including cholera and other diseases such as pneumonia, trachoma and skin infections (UNICEF 2010) while lack of toilet facility increases the risk of transmission of diseases (Trani et al. 2016). Access to safe drinking water and clean toilet facility reduce child mortality and morbidity (Trani and Cannings 2013). These two indicators are captured by SDG 6 that calls to ensure availability and sustainable management of water and sanitation for all (UN 2015).

Food security dimension includes five indicators. The first indicator captures access to food insecurity at the household level, using the Household Food Insecurity Access Scale (HFIAS) methodology³ (Coates et al. 2007). The other four indicators (weight-for-age, height-for-age, weight-for-height and body mass index) capture the functioning of 'being well-nourished' and are derived using anthropometric measure based on WHO methodology (Alkire and Santos 2014; WHO 2006). They are used to measure children's nutritional deficiencies (WHO and UNICEF 2010), that can lead to numerous health disorders (Trani et al. 2016). Food security dimension is captured by SDG 2.

Health dimension refers to access and quality of the nearest health facility and chronic illness. It captures bodily health capability and refers to a lack of resources for children's health (D'Agostino et al. 2018). Access to a health care facility is necessary for promoting children's health (UNICEF 2012). Children with chronic illness are unable to do any kind of work including play or going to school (Beatty and Fothergill 2005), which is vital for children's social development and is a crucial aspect of the human life and healthy growth and well-being (D'Agostino et al. 2018). The health dimension is captured by SDG 3 (target 3.8) (UN 2015).

Education dimension captures children's access to education and literacy. Education is a fundamental right for children (UNHROHC 1989) and plays a vital role in children's lives. We use two indicators: enrolment and literacy. Enrolment captures whether children in school-going age are being exposed to the learning environment (enrolled in school). Literacy captures whether children aged between 15 and 17 are able to read and write. In the SDGs, education has a stand-alone goal, SDG 4 (target 4.1) (UN 2015).

Security dimension is captured using two indicators (safety and crime) to capture the capability of "being able to move freely from place to place" (Nussbaum 2005). It captures the neighbourhood environment (D'Agostino et al. 2018), in recognition that feeling safe is an essential aspect of quality of life (Rees 2019). Literature has shown that violence or crime can obstruct development and can contribute to sustaining

³ The Household Food Insecurity Access Scale (HFIAS) captures three domains of food insecurity, namely insufficient quality, insufficient quantity, insecure access or supply of food. Households are categorised into four levels of household food insecurity: food secure, and mildly, moderately and severely food insecure. An individual is defined as deprived in terms of food access if he/she resides in a household that is either moderately or severely food insecure.

poverty traps (see Trani et al. 2016). According to the CRC, children have the right to be protected from all forms of violence (UNHROHC 1989). In the SDGs, this dimension is captured by SDG 16 (target 16.1) (UN 2015).

Correlation analysis (see Annex – Table 7) based on Spearman rank correlation coefficients suggests that association between indicators is generally weak. The result supports the inclusion of all indicators. We find moderate associations between indicators for housing materials and assets. The adoption of equal weighting at dimension level reduces the potential bias that may emerge from these modest associations.

4 Results

Results in Table 3 reveal that 41.7% of children aged 0–17 in Botswana can be considered to be multidimensionally poor. This result shows that the incidence of multidimensional child poverty in Botswana remains a substantial problem. The intensity of multidimensional poverty is estimated at 43.4% at the national level, meaning that, on average, children are simultaneously deprived in at least ten (10) indicators out of the twenty-three (23) indicators considered. The adjusted headcount ratio is estimated at 0.181. In the remainder of this section, we discuss differences in outcomes of multidimensional child poverty for different groups. Differences are statistically significant unless otherwise indicated.

4.1 Multidimensional Poverty by Demographic Characteristics

As expected, there are significant differences in poverty according to demographic characteristics (Table 3). In terms of gender, the proportion of children identified as multidimensionally poor is significantly higher for boys than girls. Furthermore, both the intensity and adjusted headcount ratio are higher for boys than girls. These differences are mostly driven by deprivation in relation to nutrition. Across all indicators, boys experience higher deprivation rates than girls do. This finding is in line with studies elsewhere in Sub-Saharan Africa (Wamani et al. 2007). With respect to age, children aged 0–4 experience significantly higher poverty incidences compared to other age groups. The same pattern is observed for the adjusted headcount ratio, while the intensity of poverty showed mixed results. Again, these differences are mostly driven by deprivation in relation to nutrition. As expected, the results reveal that children living with disabilities experience significantly higher levels of poverty than those without any disability. In terms of citizenship, non-citizen children have lower poverty incidences than citizens. The majority of non-citizens live in cities/towns where poverty levels are lower, and employment opportunities exist. The majority of the non-citizen children (60.4%) are from Zimbabwe, 9.9% South Africa, 14.9% other parts of Africa and 12.6% rest of the World.

With respect to living arrangements, children living with both parents experience lower levels of multidimensional poverty than those living with mothers alone or with none of their biological parents. An interesting finding is that children living with their fathers alone have lower poverty incidences than those living with both parents. To investigate this further, we examined the link between living arrangement and household size. The household size differs considerably across living arrangements. In

Table 3 Multidimensional poverty measures by demographic characteristics 2015/2016

Description ^a	Population	(%)	H (%)	A (%)	M ₀
<i>Gender</i>					
Boy	414,840	50.7	42.6***	43.7***	0.186***
Girl (ref)	403,003	49.3	40.7	43.2	0.176
<i>Age</i>					
0–4 years (ref)	258,818	31.6	46.3	44.1	0.204
5–9 years	240,576	29.4	42.0***	44.4***	0.187***
10–14 years	214,356	26.2	36.5***	41.5***	0.152***
15–17 years	104,093	12.7	40.1***	42.9***	0.172***
<i>Disability status</i>					
Disabled	6707	0.8	52.9***	46.9***	0.245***
Not disabled (ref)	811,135	99.2	41.6	43.4	0.181
<i>Citizenship</i>					
Citizen (ref)	801,606	98.0	42.3	43.4	0.184
Non-citizen	16,237	2.0	10.5***	43.7	0.046***
<i>Living arrangement</i>					
Both parents (ref)	205,978	25.2	33.0	44.0	0.145
Mother alone	374,026	45.7	45.2***	43.4***	0.196***
Father alone	27,488	3.4	29.1***	43.3***	0.126***
None of his/her parents	210,350	25.7	45.6***	43.2***	0.197***
<i>Parent survival</i>					
Both parents alive (ref)	694,653	84.9	40.5	43.5	0.176
Mother alive	86,754	10.6	49.2***	42.6***	0.209***
Father alive	20,372	2.5	44.6***	43.9***	0.196***
Both parents deceased	16,064	2.0	51.1***	44.3***	0.226***
<i>Relationship to HH</i>					
Head/spouse	2744	0.3	41.2***	44.3***	0.183***
Son/daughter (ref)	381,524	46.7	35.6	43.6	0.155
Grandchild	304,423	37.2	48.3***	43.2***	0.209***
Other relative	119,097	14.6	44.1***	43.3***	0.191***
Not related	10,054	1.2	44.2***	45.8***	0.202***
<i>Gender of HH</i>					
Male-headed	335,399	41.0	38.2***	43.7***	0.167***
Female-headed (ref)	482,443	59.0	44.1	43.3	0.191
<i>Age of HH</i>					
12–17 (children)	3656	0.4	55.0***	40.6***	0.223***
18–35 (youth)	160,824	19.7	42.4***	44.5***	0.189***
36–64 (adults) (ref)	494,850	60.5	38.2	43.1	0.165
65+ (older persons)	158,512	19.4	51.4***	43.4***	0.223***
<i>Marital status of HH</i>					
Married (ref)	258,926	31.7	26.4	42.4	0.112
Living together	199,102	24.3	53.0***	43.7***	0.232***
Separated	18,798	2.3	44.1***	42.4***	0.187***

Table 3 (continued)

Description ^a	Population	(%)	H (%)	A (%)	M ₀
Divorced	14,718	1.8	32.1***	43.6***	0.140***
Widowed/Widower	116,830	14.3	44.6***	43.4***	0.194***
Never married	209,470	25.6	48.7***	43.9***	0.214***
<i>Household size</i>					
1–3 members (ref)	116,873	14.3	29.2	43.5	0.127
4–6 members	359,333	43.9	36.6***	43.7***	0.160***
More than 7 members	341,636	41.8	51.4***	43.2***	0.222***
<i>Educational attainment of HH</i>					
None (ref)	243,503	29.8	59.0	44.3	0.264
Primary	222,164	27.2	45.6***	42.8***	0.195***
Secondary	224,686	27.5	37.0***	42.5***	0.157***
Vocational	23,420	2.9	22.5***	41.2***	0.093***
University	104,070	12.7	7.3***	47.4***	0.035***
Total	817,843	100	41.7	43.4	0.181

Source: Authors' estimates based on the 2015/2016 BMTHS data. HH stands for the household head

Significance levels: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

^a All percentages are estimated at the population level using sample weights. Sample size: 9718

essence, average household size is 5.5 for children living with their fathers alone compared to 7.3, 6.9 and 6.9 for those living with mothers alone, both parents and non-biological parents, respectively. In other words, children living with their fathers tend to live in smaller households, suggesting that resources do not need to be spread as thinly. Indeed, we observe higher poverty incidence for children in larger households compared to those in smaller households. The same results are found for intensity and adjusted headcount ratio.

Orphaned children experience higher incidence and intensity of poverty compared to children with both parents alive. The poverty situation is worse for double orphans (those who lost both biological parents) than single orphans. Similar studies confirmed this finding in developing countries. For example, Misinde (2019) found that on average living conditions of orphans were less than the average conditions of non-orphans in Uganda. Similarly, children not staying with their biological parents experience higher levels of poverty than those living with their biological parents.

With respect to the gender of household head, results show that children living in households headed by women experience higher poverty incidence and intensity than those living in households headed by men. Similarly, children residing in households headed by other children and older persons have higher levels of poverty than those in households headed by adults or youth. Compared with children living in households headed by married couples, children residing in households headed by cohabiting couples experience higher levels of poverty followed by those living in households whose heads never married, widowed/widower, separated and divorced. The finding that child poverty is higher among cohabiting partners might be explained by the fact that children in households with cohabiting partners are often biologically related to

only one partner (mostly mothers). This scenario sometimes put such children at a disadvantage regarding sharing of resources that are brought in by the non-biological partner.

Finally, the incidence of multidimensional child poverty and adjusted headcount ratios decline sharply with improvements in educational levels of household heads. Children residing in households whose heads never attended school experiencing the highest poverty levels; eight times higher than those residing in households whose heads have a university qualification.

4.2 Multidimensional Poverty by Economic Variables

Table 4 presents results along the lines of economic variables (economic activity and economic status). Employment plays an important role, and multidimensional child poverty significantly varies across the employment status of the household head. We observe that children residing in households whose heads are unemployed experience significantly higher levels of poverty than those whose heads are involved in paid employment, self-employment and own farm employment. Surprisingly, children residing in households whose heads are engaged as family helpers have higher levels of poverty than those whose heads are unemployed. This finding could be linked to lower salaries associated with those engaged as family helpers.

We also observe a negative relationship between household expenditures and multidimensional child poverty. Children in the poorest quintile (Q1) experience higher levels of multidimensional child poverty, and the incidence declines along the quintiles

Table 4 Multidimensional poverty measures by economic variables 2015/2016

Variable ^a	Population	(%)	H (%)	A (%)	M ₀
<i>Employment status of HH</i>					
Unemployed (ref)	392,939	48.0	54.3	43.4	0.236
Paid employment	235,866	28.8	21.6***	42.1***	0.091***
Self-employment	85,473	10.5	24.2***	40.7***	0.098***
Own farm	52,214	6.4	46.5***	45.4***	0.211***
Family helper	51,351	6.3	62.0***	45.9***	0.285***
<i>Quintiles</i>					
Q1 (ref)	661,102	35.3	61.2	44.1	0.270
Q2	457,266	24.4	40.7***	42.6***	0.173***
Q3	335,069	17.9	24.5***	41.2***	0.101***
Q4	234,215	12.5	9.6***	41.5***	0.040***
Q5	187,213	10.0	4.3***	39.1***	0.017***
Total	817,843	100	41.7	43.4	0.181

Source: Authors' estimates based on the 2015/2016 BMTHS data

Significance levels: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

^a All percentages are estimated at the population level using sample weights. Sample size: 9718. Per capita quintiles were calculated at the household level. Per capita quintiles are defined as follows. Q1: $y \leq 371.75$; Q2: $371.76 \leq y \leq 665.32$; Q3: $665.33.53 \leq y \leq 1172.82$; Q4: $1172.83 \leq y \leq 2238.13$; $y \geq 2238.14$. HH stands for the household head

with those in the richest quintile (Q5) experiencing lowest levels of poverty. The incidence of poverty in Q1 is 23 times higher than in Q5. Similarly, children from Q1 have higher adjusted headcount ratio compared those in Q2-Q5. Similar studies have found declining multidimensional child poverty rates along income quintiles/deciles. For example, Roelen (2017) showed declining multidimensional incidences of child poverty along income deciles (measured using per capita real consumption), with the richest decile recording the lowest poverty rates in Vietnam.

4.3 Multidimensional Poverty Across Geographic Areas

Table 5 considers Botswana's multidimensional child poverty situation across cities/towns, urban villages and rural areas. Children residing in rural areas experience significantly higher levels of poverty than those in urban villages and cities/towns. For example, the incidence of multidimensional child poverty in rural areas is triple that in cities/towns. Furthermore, both intensity and adjusted headcount ratios are higher in rural areas. Similar findings exist in the literature (see Ferrone and de Milliano 2018).

We further explore whether multidimensional child poverty varies across administrative districts. Results reveal that incidence varies significantly across the 26 administrative districts with Ngwaketse West and Kweneng West recording the highest incidences of multidimensional child poverty, estimated at 86% and 76%, respectively. The two districts also recorded the highest adjusted headcount ratios estimated higher than 0.300.

4.4 Micro-Determinants of Multidimensional Child Poverty

To complement the descriptive analysis, we employed a logit regression model to investigate the joint correlation of demographic, economic and geographical factors in relation to multidimensional child poverty. Table 6 presents the results showing the estimated coefficients, their robust standard errors and the marginal effects. The log pseudolikelihood ratio test indicates that there is a significant relationship between the probabilities of being multidimensionally poor and the explanatory variables included in the model ($p < 0.001$).

Findings of regression analysis mainly confirm those of descriptive analysis. Boys, children aged 0–4, citizens and children living with a disability are more likely to experience multidimensional poverty. In terms of living arrangements, children living with mothers alone or with none of their biological parents have higher probabilities of being multidimensionally poor than those living with both parents. The finding that children living with their fathers alone experience lower levels of poverty is also confirmed through regression analysis; they have a lower probability of being multidimensionally poor than those living with both biological parents. Orphans have higher probabilities of being multidimensionally poor than those with both parents alive. Relationship to the household head also matters: grandchildren and children otherwise related to the head of the household are more likely to be poor than sons or daughters of the household head.

With respect to the characteristics of the household head, children living in households headed by men have a higher probability of being poor than those in households headed by women. This empirical evidence from Botswana is contrary to the general

Table 5 Multidimensional poverty measures by geographical variables 2015/2016

Geographical variable ^a	Population	(%)	H (%)	A (%)	M ₀
<i>Strata</i>					
Cities/towns	141,902	17.4	19.3***	42.2	0.081***
Urban villages (ref)	364,705	44.6	34.4	42.1	0.145
Rural areas	311,236	38.1	60.5***	44.5***	0.269***
<i>Districts</i>					
Gaborone	67,752	8.3	18.7***	42.7***	0.080***
Francistown	32,275	3.9	22.4***	43.5***	0.097***
Lobatse	9038	1.1	26.0***	37.6***	0.098***
Selibe Phikwe	20,842	2.5	20.7***	40.4***	0.083***
Orapa	3960	0.5	8.0***	55.6***	0.044***
Jwaneng	6903	0.8	7.3***	39.8***	0.029***
Sowa Town	1132	0.1	0.0***	0.00	0.000***
Southern	51,382	6.3	49.1***	43.6***	0.214***
Barolong	23,068	2.8	45.6***	40.9***	0.187***
Ngwaketse West	5779	0.7	36.4***	42.3	0.154***
South East	30,432	3.7	23.7***	42.1***	0.100***
Kweneng East (ref)	107,595	13.2	38.1	42.4	0.161
Kweneng West	23,836	2.9	76.8***	48.1***	0.370**
Kgatleng	33,218	4.1	25.4***	40.9***	0.104***
Central Serowe/Palapye	80,629	9.9	45.1***	44.4***	0.200***
Central Mahalapye	61,719	7.5	56.8***	43.2***	0.245***
Central Bobonong	29,005	3.5	43.8***	40.7***	0.178***
Central Boteti	22,378	2.7	49.8***	45.5***	0.227***
Central Tutume	67,746	8.3	52.6***	43.7***	0.230***
North East	22,931	2.8	33.7***	41.6***	0.140***
Ngamiland East	43,497	5.3	39.6***	44.0***	0.174***
Ngamiland West	28,343	3.5	86.0***	45.8***	0.394***
Chobe	9042	1.1	39.3**	37.8***	0.149***
Ghanzi	19,584	2.4	46.6***	42.8***	0.199***
Kgalagadi South	9636	1.2	53.4***	41.5***	0.222***
Kgalagadi North	6121	0.7	45.2***	43.6***	0.197***
Total	817,843	100	41.7	43.4	0.181

Source: Authors' estimates based on the 2015/16 BMTHS data

Significance levels: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

^a All percentages are estimated at population level using sample weights. Sample size: 9718

belief that female-headed households are more likely to be poor than male-headed households (see Bradshaw et al. 2017). Our results are consistent with the case of Nicaragua (Espinoza-Delgado and Klasen 2018). This finding could – in part – be explained by household composition. In the case of Botswana, households headed by men are characterised by slightly larger household sizes than those that are headed by

Table 6 Results of the logit regressions

Explanatory variables	Coefficient	Robust SE	Marginal effects
<i>Gender</i> (ref: Female)			
Male	0.1017**	0.0480	0.0237
<i>Age</i> (ref: 0–4 years)			
5–9 years	–0.2406***	0.0621	–0.0562
10–14 years	–0.5402***	0.0666	–0.1231
15–17 years	–0.2463***	0.0862	–0.0572
<i>Disability status</i> (ref: Not disabled)			
Disabled	0.6874**	0.2692	0.1695
<i>Citizenship</i> (ref: None citizen)			
Citizen	0.7817***	0.2873	0.1631
<i>Living arrangement</i> (ref: Both parents)			
Mother alone	0.1602*	0.0893	0.0380
Father alone	–0.2829*	0.1639	–0.0646
None of his/her parents	0.2218**	0.1074	0.0530
<i>Parent survival</i> (ref: Both parents alive)			
Mother alive	0.1241	0.0779	0.0297
Father alive	0.4343***	0.1613	0.1063
Both parents deceased	0.6781***	0.1730	0.1671
<i>Relationship to HH</i> (ref: Son/daughter)			
Head/spouse	–0.6315	0.5808	–0.1353
Grandchild	–0.3904***	0.0855	–0.0912
Other relative	–0.4304***	0.0899	–0.0976
Not related	–0.3582	0.2323	–0.0807
<i>Gender of HH</i> (ref: Female-headed)			
Male-headed	0.6101***	0.1329	0.1453
<i>Age of HH</i> (ref: 36–64 (adults))			
12–17 (children)	1.3128***	0.4656	0.3146
18–35 (youth)	0.2649***	0.0760	0.0637
65+ (older persons)	0.0357	0.0708	0.0085
<i>Marital status of HH</i> (ref: Married)			
Living together	1.1690***	0.1237	0.2822
Separated	1.0092***	0.1832	0.2471
Divorced	0.5027**	0.2193	0.1234
Widowed/Widower	0.5799***	0.1219	0.1415
Never married	1.0621***	0.1136	0.2567
Household size (continuous)	0.0388***	0.0079	0.0092
<i>Educational attainment of HH</i> (ref: None)			
Primary	–0.4229***	0.0634	–0.0975
Secondary	–0.6640***	0.0810	–0.1500
Vocational	–0.7646***	0.1802	–0.1605
University	–1.6347***	0.1461	–0.3011
<i>Employment status of HH^a</i> (ref: Unemployed)			

Table 6 (continued)

Explanatory variables	Coefficient	Robust SE	Marginal effects
Paid employment	-0.3769***	0.0907	-0.0855
Self-employment	-0.0541	0.0964	-0.0127
Own farm	0.4120***	0.1002	0.1005
<i>Quintiles (ref: Q1)</i>			
Q2	-0.6169***	0.0590	-0.1391
Q3	-0.0865***	0.0787	-0.2245
Q4	-1.6870***	0.1248	-0.3026
Q5	-2.2304***	0.2148	-0.3472
<i>Region (ref: Urban villages)</i>			
Rural areas	0.9409***	0.0651	0.2232
Cities and towns	-0.0690	0.1030	-0.0162
<i>Interaction terms</i>			
Cohabitation (Male-headed household)	-0.2505	0.1509	-0.0578
Separated (Male-headed household)	-1.0358*	0.5993	-0.2032
Divorced (Male-headed household)	-1.7983	1.2042	-0.2911
Widowed (Male-headed household)	-0.4837*	0.2848	-0.1066
Single (Male-headed household)	-0.3381*	0.1859	-0.0766
Rural (Male-headed household)	-0.1706	0.1084	-0.0398
Cities and towns (Male-headed household)	-0.4519***	0.1616	-0.1014
Constant	-1.3842***	0.3194	
Number of observations	9718		
Wald chi2(38)	2989.04		
Prob. > chi2	0.0000***		
Pseudo R2	0.2247		
Log pseudolikelihood	-5157.47		

Source: Authors' estimates based on 2015/2016 BMTHS. Robust standard errors (SE) are reported
Significance levels: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

^a Family helper is omitted from the model due to collinearity. Ref. means reference category. Dependent variable: dummy equal 1 if the child is considered to be multidimensionally poor and 0 otherwise

women. For example, in the case of married couples, household size averaged 7.1 for male-headed households compared to 6.2 of those led by women (SB 2018).

Children living in households headed by other children and youth have higher probabilities of being multidimensionally poor compared to those children living in households headed by adults. Children residing in households headed by married couples have lower probabilities of being multidimensionally poor, an indication that marriage plays a pivotal role in poverty (Lekobane and Seleka 2017). Larger households are associated with a greater likelihood of being poor: a unit increase in household size will result in 0.9 percentage points increase in the probability of being multidimensionally poor. The probability of being multidimensionally poor declines with improvements in educational attainment.

In terms of employment status, children living in households whose heads are engaged in paid employment have lower probabilities of being multidimensionally poor than those from households whose heads are unemployed. Children living in households whose heads are involved in farming on their farms or land are more likely to be multidimensionally poor than those from households with unemployed heads. This finding is consistent with Lekobane and Seleka (2017) who found that in Botswana, households whose heads worked in their own farms are more likely to be poor (based on monetary poverty) than those households whose heads were unemployed. This finding could be explained by low yields in agricultural production due to low technology adoption, especially subsistence arable agriculture, which is predominant in most rural households in Botswana. Also, farming households comprise of mostly dependents (children and older persons) who are economically inactive.

We find a strong association with expenditure profiles; children in higher quintiles are all significantly less likely to be poor than children in the lowest quintile. With respect to geography, the results show that *ceteris paribus* children residing in rural areas are more likely to be multidimensionally poor than those residing in urban villages. Results show statistically insignificant differences in probabilities of being multidimensionally poor between urban villages and cities and towns.

To capture intersecting inequalities, we included interaction terms on the gender of household head and marital status of the household head to capture the joint impact of the two variables. The results show that children living in households headed by women who are separated, widows or single (never married) have, *ceteris paribus*, higher probabilities of being multidimensionally poor than those living in households headed by men who are separated, widowers or single, respectively. Children living in cities/towns-women led households have higher probabilities of being multidimensionally poor than those living in cities/towns-men headed households.

5 Conclusion and Policy Implications

Measurement of multidimensional child poverty in low- and middle-income countries is now relatively widespread with national and context-specific studies existing alongside large cross-country comparisons. Nevertheless, efforts to measure (child) poverty remain primarily dominated by monetary approaches, and many countries fail to monitor multidimensional child poverty. The two main approaches (MODA and MPI) offer opportunities for expanding efforts to monitor multidimensional child poverty. However, these approaches may also detract from other initiatives that aim to build on their respective strengths in offering child-focused analysis based on an aggregate index.

In this article, we developed a child-centred, individual-level and composite measure that offers nationally relevant and context-specific insights into magnitude and depth of multidimensional child poverty in Botswana. In particular, it did so through the lens of LNOB by zooming in on demographic, economic and

geographical characteristics that may be associated with greater vulnerability or marginalisation.

Results point towards relatively high incidence and intensity of multidimensional child poverty for an upper-middle-income country like Botswana. More than four out of ten children can be considered multidimensionally poor, and on average they are deprived in almost half of all deprivations. These numbers suggest the importance of multidimensional poverty measurement alongside economic indicators such as economic growth or monetary poverty.

The descriptive and parametric analysis leads to both expected and more surprising findings in terms of which children may be left behind. Children living with disabilities, orphaned children and children not living with their relatives, for example, are more likely to be poor. More counter-intuitively, children who are citizens of Botswana are more likely to be poor than non-citizens. In addition, children living with their fathers alone have lower poverty incidences than those living with both parents. It should also be noted that despite the seeming discrepancy between economic status and multidimensional poverty, children in poorer quintiles (based on expenditures) are more likely to be multidimensionally poor. Children living in rural areas experience higher levels of poverty and have higher probabilities of being poor.

The application illustrates the added-value of building on key components of the MODA, and MPI approaches, namely their focus on individual-level measurement and aggregated index analysis. In doing so, this allows for providing overall estimates of multidimensional child poverty that are based on individual children as units of analysis, which in turn provided for an in-depth investigation into groups of children that are most affected and left behind. Also, the individual-level multidimensional child poverty measure allows for the operationalisation of the LNOB principle in Botswana, which can be applied elsewhere.

These findings have critical policy implications. Various groups of children are at greater of risk of deprivation – and therefore to be left behind – than others are. For Botswana to live up to the principle of LNOB as set out in the BPEPS, Vision 2036 and the 2030 Agenda, it will be vital to put in place relevant policies that will take into account the heterogeneity of different groups of children. The adoption of an individual- and context-specific measure of multidimensional child poverty will be vital in guiding those efforts.

Notwithstanding the importance of cross-sectional analysis of child poverty for a one-time point, future work should be conducted to analyse trends in multidimensional child poverty. Lack of more frequent and timely data prevented this study from analysing trends in multidimensional child poverty.

In sum, results in the article illustrate how the combination of strengths of emerging and increasingly prominent approaches in multidimensional child poverty measurement can be combined to offer child-centred analysis that provides insight into incidence and depth of deprivation. Detailed disaggregated descriptive and non-parametric analysis provides critical understandings of groups who may need further consideration in countries' – and in this case, Botswana – efforts to achieving SDG 1 against the principle of LNOB.

Appendix

Table 7 Spearman's rank correlation coefficients between deprivation indicators 2015/16^a

ID	DG	TR	LD	OC	CF	FL	RF	WL	EL	WR	TF	EN ^a
IF	.390***	.237***	-.061***	.256***	.274***	.263***	.219***	.261***	.428***	.150***	.230***	.083***
DG	1.00	.412***	-.137***	.335***	.479***	.303***	.256***	.329***	.586***	.170***	.431***	.119***
TR	1.00	1.00	-.109***	.282***	.410***	.198***	.168***	.201***	.360***	.083***	.435***	.084***
LD	1.00	1.00	1.00	-.010***	-.324***	-.115***	-.085***	-.105***	-.117***	-.019***	-.288***	-.024***
OC	1.00	1.00	1.00	1.00	.306***	.272***	.231***	.270***	.406***	.108***	.362***	.107***
CF	1.00	1.00	1.00	1.00	1.00	.327***	.288***	.327***	.559***	.200***	.524***	.119***
FL	1.00	1.00	1.00	1.00	1.00	1.00	.701***	.749***	.440***	.348***	.225***	.145***
RF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.678***	.388***	.311***	.185***	.095***
WL	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.454***	.315***	.224***	.123***
EL	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.276***	.446***	.141***
WR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.145***	.107***
TF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.108***
EN	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
LT												
HF												
CI												
FA												
WZ ^a												
HZ ^a												
WH ^a												
BM												

Table 7 (continued)

ID	DG	TR	LD	OC	CF	FL	RF	WL	EL	WR	TF	EN ^a
SF												
CR												
ID	LT ^b	HF	CI	FA	WZ ^c	HZ ^c	WH ^c	BM	SF	CR		
IF	.094***	-.005***	-.009	.201***	.055***	.022***	.034***	.024***	.000	-.037***		
DG	.072***	.045***	-.019***	.358***	.055***	.047***	.040***	.058***	-.009***	-.041***		
TR	.046***	.066***	.000	.358***	.075***	.096***	.001***	.069***	-.001	-.083***		
LD	.023***	-.070***	.000	-.184***	-.021***	-.048***	.041***	-.033***	.039***	-.028***		
OC	.038***	.025***	-.021***	.264***	.083***	.090***	.030***	.043***	.024***	-.048***		
CF	.051***	.076***	-.010***	.393***	.098***	.098***	.019***	.080***	-.015***	-.052***		
FL	.036***	-.003***	-.011***	.189***	.030***	.018***	.005*	.004***	-.047***	-.034***		
RF	-.009***	-.029***	-.005***	.153***	.015***	.041***	-.022***	.012***	-.033***	-.048***		
WL	.037***	-.001	-.019***	.200***	.030***	.029***	.003	.011***	-.043***	-.047***		
EL	.102***	.042***	-.008***	.338***	.077***	.082***	-.002	.050***	-.003	-.088***		
WR	.000***	-.003***	-.004***	.038***	.037***	-.006***	-.001	-.011***	.012***	-.026***		
TF	.054***	.089***	.003***	.399***	.067***	.074***	.003	-.025***	-.007***	-.085***		
EN	.203***	-.007***	.007***	.077***	na	na	na	-.025***	.000	.007***		
LT	1.00	-.006**	.096***	.059***	na	na	na	-.035***	.006*	-.034***		
HF		1.00	.001	.129	-.014***	-.018***	.000	.020***	.082***	.001		
CI			1.00	.014***	.014***	.012***	-.011***	.009***	.021***	.015***		
FA				1.00	.045***	.060***	.022***	.077***	.018***	-.024***		
WZ ^a					1.00	.373***	.331***	na	-.030***	-.010***		
HZ ^a						1.00	-.028***	na	-.068***	-.040***		

Table 7 (continued)

ID	LT ^b	HF	CI	FA	WZ ^c	HZ ^c	WH ^c	BM	SF	CR
WH ^a						1.00		na	.000	-.037***
BM								1.00	-.009***	-.016***
SF									1.00	.193***
CR										1.00

Source: Authors' estimates based on the 2015/16 BMTHS data

† Results are estimated at the population level using sample weights. *ID*: indicator; *IF*: information; *DG*: durable goods; *TR*: transport; *LD*: land tenure; *OC*: overcrowding; *CF*: cooking fuel; *FL*: floor; *RF*: roof; *WL*: wall; *WR*: water; *TF*: toilet facility; *EN*: enrolment; *LT*: literacy; *HF*: health facility; *CI*: chronic illness; *FA*: food access; *WZ*: weight-for-age; *HZ*: height-for-age; *WH*: weight-for-height; *BM*: body mass index; *SF*: safety; *CR*: crime

*, **, ***Correlation is significant at the 0.01, 0.05 and 0.1 level (2-tailed) (respectively). Sample size: 9718

^{a, b, c} The sample size is 6614, 1225 and 3104 for age groups 5–17, 15–17 and 0–4 years (respectively)

^{na} No data to compute correlations

Table 8 Proportion of deprived children by indicator and age groups

Dimensions ^a	Indicator	0–4 years (<i>n</i> = 3104)	5–9 years (<i>n</i> = 2842)	10–14 years (<i>n</i> = 2547)	15–17 years (<i>n</i> = 1225)
1. Asset	Information	26.6 (0.442)	24.9 (0.432)	23.5 (0.424)	23.9 (0.426)
	Durable goods	61.0 (0.488)	59.5 (0.491)	58.1 (0.493)	57.2 (0.495)
	Transport	74.4 (0.436)	73.4 (0.442)	74.4 (0.437)	72.7 (0.446)
	Land tenure	34.1 (0.474)	33.3 (0.471)	29.7 (0.457)	32.0 (0.466)
2. Housing	Overcrowding	46.4 (0.499)	45.9 (0.498)	43.2 (0.495)	40.2 (0.490)
	Cooking fuel	55.9 (0.497)	54.9 (0.498)	53.7 (0.499)	50.1 (0.500)
	Floor material	15.4 (0.361)	13.9 (0.346)	10.6 (0.308)	10.9 (0.312)
	Roof material	13.2 (0.339)	11.8 (0.323)	10.3 (0.304)	9.0 (0.287)
	Wall material	21.1 (0.408)	19.1 (0.393)	15.6 (0.363)	15.3 (0.360)
3. Water & sanitation	Electricity	41.8 (0.493)	39.9 (0.490)	38.1 (0.486)	35.0 (0.477)
	Water supply	10.6 (0.308)	7.4 (0.261)	5.8 (0.234)	6.6 (0.248)
4. Food security	Toilet facility	70.4 (0.456)	68.7 (0.464)	69.9 (0.459)	67.8 (0.467)
	HFIAP	55.5 (0.497)	54.1 (0.498)	53.5 (0.499)	54.5 (0.498)
5. Health	WAZ	7.6 (0.265)	–	–	–
	HAZ	17.4 (0.379)	–	–	–
	WAZ	5.2 (0.223)	–	–	–
	BMI	–	8.9 (0.285)	12.6 (0.332)	10.9 (0.312)
6. Education	Health facility	35.4 (0.478)	36.0 (0.480)	33.8 (0.473)	35.1 (0.477)
	Chronic illness	1.2 (0.110)	2.7 (0.161)	3.8 (0.192)	5.2 (0.222)
7. Security	Enrolment	–	14.3 (0.351)	1.6 (0.126)	19.7 (0.398)
	Literacy	–	–	–	1.0 (0.100)
7. Security	Safety	38.9 (0.488)	38.4 (0.486)	39.2 (0.488)	40.2 (0.490)
	Crime	9.5 (0.293)	10.4 (0.305)	10.7 (0.309)	10.1 (0.301)

Source: Authors' estimates based on the 2015/16 BMTHS data

^a All percentages are estimated at the population level using sample weights. Standard deviations (SD) are reported in parentheses. *n* is the sample size for different age groups. – The indicator is not applicable to the age group

Table 9 Multidimensional poverty incidence (H%), intensity (A) and adjusted headcount ratio (M_0) using three alternative values of k

Variable ^a	$k = 0.33$			$k = 0.25$			$k = 0.40$		
	H	A	M_0	H	A	M_0	H	A	M_0
<i>Gender</i>									
Male	42.6	43.7	0.186	59.7	39.5	0.236	25.2	48.8	0.123
Female	40.7	43.2	0.176	58.0	39.0	0.226	23.5	48.2	0.113
<i>Age</i>									
0 to 4 years	46.3	44.1	0.204	65.2	39.5	0.258	29.3	48.7	0.143
5 to 9 years	42.0	44.4	0.187	58.0	40.3	0.234	25.4	49.6	0.126
10 to 14 years	36.5	41.5	0.152	53.7	37.7	0.202	17.8	47.0	0.084
15–17 years	40.1	42.9	0.172	55.7	39.1	0.218	23.3	47.6	0.111
<i>Region</i>									
Cities/towns	19.3	42.2	0.081	31.8	37.1	0.118	9.4	48.4	0.046
Urban villages	34.4	42.1	0.145	53.6	37.4	0.200	18.3	47.4	0.087
Rural areas	60.5	44.5	0.269	77.5	41.2	0.319	38.2	49.2	0.188
<i>District</i>									
Gaborone	18.7	42.7	0.080	28.9	37.9	0.110	9.7	48.9	0.047
Francistown	22.4	43.5	0.097	38.4	37.6	0.144	13.3	48.2	0.064
Lobatse	26.0	37.6	0.098	48.3	33.7	0.163	6.4	43.0	0.027
Selibe Phikwe	20.7	40.4	0.083	32.1	36.5	0.117	6.7	47.0	0.031
Orapa	8.0	55.6	0.044	13.3	44.8	0.059	8.0	55.6	0.044
Jwaneng	7.3	39.8	0.029	20.6	32.9	0.068	3.5	46.9	0.016
Sowa Town	0.0	0.00	0.000	9.3	29.8	0.028	0.0	0.00	0.000
Southern	49.1	43.6	0.214	67.6	39.6	0.268	28.2	49.4	0.139
Barolong	45.6	40.9	0.187	67.8	37.2	0.252	18.4	48.1	0.088
Ngwaketse West	36.4	42.3	0.154	81.2	35.1	0.285	20.3	47.4	0.096
South East	23.7	42.1	0.100	38.1	37.1	0.141	13.2	47.3	0.062
Kweneng East	38.1	42.4	0.161	59.2	37.6	0.223	21.6	47.1	0.101
Kweneng West	76.8	48.1	0.370	89.9	45.3	0.407	61.6	51.1	0.315
Kgatleng	25.4	40.9	0.104	42.7	36.2	0.155	11.7	46.9	0.055
Central Serowe/Palapye	45.1	44.4	0.200	61.8	40.2	0.249	28.0	49.2	0.138
Central Mahalapye	56.8	43.2	0.245	72.1	40.3	0.290	33.9	47.8	0.162
Central Bobonong	43.8	40.7	0.178	68.6	36.3	0.249	20.2	45.8	0.093
Central Boteti	49.8	45.5	0.227	67.1	41.1	0.276	36.1	49.0	0.177
Central Tutume	52.6	43.7	0.230	68.8	40.4	0.278	31.1	48.7	0.152
North East	33.7	41.6	0.140	56.4	36.4	0.206	17.0	46.8	0.080
Ngamiland East	39.6	44.0	0.174	59.4	38.8	0.230	24.4	49.0	0.120
Ngamiland West	86.0	45.8	0.394	94.1	44.5	0.419	64.6	48.8	0.316
Chobe	39.3	37.8	0.149	50.3	36.0	0.181	8.5	46.3	0.039
Ghanzi	46.6	42.8	0.199	66.7	38.7	0.258	23.0	48.6	0.112
Kgalagadi South	53.4	41.5	0.222	70.5	38.5	0.271	24.1	47.8	0.115
Kgalagadi North	45.2	43.6	0.197	77.2	37.7	0.291	20.4	52.2	0.107

Table 9 (continued)

Variable ^a	$k = 0.33$			$k = 0.25$			$k = 0.40$		
	H	A	M_0	H	A	M_0	H	A	M_0
Total	41.7	43.4	0.181	58.9	39.2	0.231	24.4	48.5	0.118

Source: Authors' estimates based on the 2015/16 BMTHS data

^a All percentages are estimated at the population level using sample weights. Sample size: 9718

Acknowledgments The authors would like to thank participants of the 7th Conference of the International Society for Child Indicators, held in Tartu, Estonia from August 27–29, 2019, who gave valuable comments and suggestions for deepening our analysis, and three anonymous referees for helpful comments and discussions. A special thanks to Statistics Botswana for providing the 2015/16 BMTHS dataset used in the analysis of this study. Khaufelo Raymond Lekobane would like to thank BIDPA for the sponsorship to pursue his PhD from which this study was developed. All errors remain the authors' responsibility.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Alkire, S. (2002). Dimensions and human development. *World Development*, 30(2), 181–205.
- Alkire, S., & Apablaza, M. (2016). *Multidimensional poverty in Europe 2006–2012: Illustrating a methodology*. Oxford poverty and human development initiative (OPHI) working paper 74. Oxford: University of Oxford.
- Alkire, S., & Foster, J. E. (2011). Counting and multidimensional poverty measurement. *Journal of Public Economics*, 95(7–8), 476–487.
- Alkire, S., & Santos, M. E. (2014). Measuring acute poverty in the developing world: Robustness and scope of the multidimensional poverty index. *World Development*, 59, 251–274.
- Alkire, S., Foster, J. E., Seth, S., Santos, M. E., Roche, J. M., & Ballon, P. (2015). *Multidimensional poverty measurement and analysis*. Oxford: Oxford University Press.
- Alkire, S., & Jahan, S. (2018). *The new global MPI 2018: Aligning with the sustainable development goals*. Oxford poverty and human development initiative (OPHI) working paper 121. Oxford: University of Oxford.
- Alkire, S., Jindra, C., Robles, G., & Vaz, A. (2017). *Children's multidimensional poverty: Disaggregating the global MPI*. Oxford poverty and human development initiative (OPHI) briefing 46. Oxford: University of Oxford.
- Alkire, S., Ul Haq, R., & Alim, A. (2019). *The state of multidimensional child poverty in South Asia: A contextual and gendered view*. Oxford poverty and human development initiative (OPHI) working paper 127. Oxford: University of Oxford.

- Allendorf, K. (2007). Do women's land rights promote empowerment and child health in Nepal? *World Development*, 35(11), 1975–1988.
- Amarante, V., Arim, R., & Vigorito, A. (2010). Multidimensional poverty among children in Uruguay. In J. A. Bishop (Ed.), *Studies in applied welfare analysis: Papers from the third ECINEQ meeting. Research on economic inequality 18* (pp. 31–53). Bingley: Emerald Group Publishing.
- Beatty, C., & Fothergill, S. (2005). The diversion from 'unemployment' to 'sickness' across British regions and districts. *Regional Studies*, 39(7), 837–854.
- Bradshaw, S., Chant, S., & Linneker, B. (2017). Gender and poverty: What we know, don't know, and need to know for Agenda 2030. *Gender, Place & Culture*, 24(12), 1667–1688.
- Chen, K., Leu, C., & Wang, T. (2019). Measurement and determinants of multidimensional poverty: Evidence from Taiwan. *Social Indicators Research*, 145(2), 459–478.
- Chzhen, Y., & Ferrone, L. (2017). Multidimensional child deprivation and poverty measurement: Case study of Bosnia and Herzegovina. *Social Indicators Research*, 131(3), 999–1014.
- Chzhen, Y., de Neubourg, C., Plavgo, I., & de Milliano, M. (2016). Child poverty in the European Union: The multiple overlapping deprivation analysis approach (EU-MODA). *Child Indicators Research*, 9(2), 335–356.
- Coates, J., Swindale, A., & Bilinsky, P. (2007). *Household food insecurity access scale (HFIAS) for measurement of household food access: Indicator Guide (v. 3)*. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development.
- D'Agostino, A., Giusti, C., & Potsi, G. (2018). Gender and children's wellbeing: Four Mediterranean countries in perspective. *Child Indicators Research*, 11(5), 1649–1676.
- de Milliano, M., & Plavgo, I. (2014). *Analysing child poverty and deprivation in sub-Saharan Africa: CCMODA-Cross Country Multiple Overlapping Deprivation Analysis*. Innocenti working paper no. 2014–19. Florence: UNICEF Innocenti Research Centre.
- de Neubourg, C., Chai, J., de Milliano, M., Plavgo, I., & Wei, Z. (2012). *Step-by-step guidelines to the multiple overlapping deprivation analysis (MODA)*. Innocenti working paper no. 2012–10. Florence: UNICEF Innocenti Research Centre.
- de Neubourg, C., Dangeot, A., Ramful, N., Karpati, J., Plavgo, I., & de Neubourg, N. (2015). *Child poverty in Botswana: A multiple overlapping deprivation analysis*. Florence: UNICEF.
- Doyal, L., & Gough, I. (1991). *A theory of human need*. New York: Guilford Press.
- Espinoza-Delgado, J., & Klasen, S. (2018). Gender and multidimensional poverty in Nicaragua: An individual based approach. *World Development*, 110, 466–491.
- Ferrone, L., & de Milliano, M. (2018). Multidimensional child poverty in three countries in Sub-Saharan Africa. *Child Indicators Research*, 11(3), 755–781.
- Global Coalition to End Child Poverty. (2019). *Voluntary National Reviews for the sustainable development goals: Are countries committed to ending child poverty by 2030?* New York: Global Coalition to End Child Poverty.
- Gordon, D., Nandy, S., Pantazis, C., Pemberton, S., & Townsend, P. (2003). *Child poverty in the developing world*. Bristol: The Policy Press.
- Hjelm, L., Ferrone, L., Handa, S., & Chzhen, Y. (2016). *Comparing approaches to the measurement of multidimensional child poverty*. Innocenti working paper no. 2016-29. Florence: UNICEF Innocenti research Centre.
- Lekobane, K. R., & Seleka, T. B. (2017). Determinants of household welfare and poverty in Botswana, 2002/2003 and 2009/2010. *Journal of Poverty*, 21(1), 42–60.
- Lerman, R., & McKernan, S. M. (2008). *The effects of holding assets on social and economic outcomes of families: A review of theory and evidence (report in the series poor finances: Assets and low-income households)*. Washington, DC: Urban Institute, Washington University Center for Social Development, and New America Foundation.
- Leu, C.-H., Chen, K.-M., & Chen, H.-H. (2016). A multidimensional approach to child poverty in Taiwan. *Children and Youth Services Review*, 66, 35–44.
- Maasoumi, E., & Yalonetzky, G. (2013). Introduction to robustness in multidimensional wellbeing analysis. *Econometric Reviews*, 32(1), 1–6.
- MFED. (2016). *National Development Plan 11*. Gaborone: Government Printer.
- Misinde, C. (2019). Child living conditions and orphanhood status in Uganda: An extension of the application of the intrinsic value approach to child poverty measurement. *Child Indicators Research*, 12(1), 277–298.
- Nussbaum, M. (2005). Women's bodies: Violence, security, capabilities. *Journal of Human Development*, 6(2), 167–183.

- Rees, G. (2019). Children's feelings of safety and their subjective well-being. In D. Kutsar & K. Raid (Eds.), *Children's subjective well-being in local and international perspectives* (pp. 30–39). Tallinn: Statistikaamet.
- RoB. (2016). *Vision 2036: Achieving prosperity for all*. Gaborone: Lentswe La Lesedi Pty (Ltd).
- RoB. (2018). *Draft Botswana poverty eradication policy and strategy 2018–2023*. Gaborone: Unpublished.
- Roche, J. (2013). Monitoring progress in child poverty reduction: Methodological insights and illustration to the case of Bangladesh. *Social Indicators Research*, 112(2), 363–390.
- Roelen, K., & Gassmann, F. (2008). *Measuring child poverty and well-being: A literature review*. Working paper MGSOG/2008/WP001. Maastricht: The Maastricht Graduate School of Governance.
- Roelen, K. (2010). *False positives or hidden dimension. The definition and measurement of child poverty*. PhD thesis. The Maastricht Graduate School of Governance.
- Roelen, K. (2017). Monetary and multidimensional child poverty: A contradiction in terms? *Development and Change*, 48(3), 502–533.
- Roelen, K., Gassmann, F., & de Neubourg, C. (2009). The importance of choice and definition for the measurement of child poverty—the case of Vietnam. *Child Indicators Research*, 2(3), 245–263.
- Seleka, T. B., & Lekobane, K. R. (2017). Public transfers and participation decisions in Botswana's subsistence economy. *Review of Development Economics*, 21(4), 1380–1400.
- SB. (2014). *2013 Botswana AIDS impact survey IV summary results*. Gaborone: Statistics Botswana.
- SB. (2016). *Selected statistical indicators 1966–2016*. Gaborone: Statistics Botswana.
- SB. (2018). *Botswana multi-topic household survey report 2015/2016*. Gaborone: Statistics Botswana.
- Trani, J. F., & Cannings, T. I. (2013). Child poverty in an emergency and conflict context: A multidimensional profile and an identification of the poorest children in Western Darfur. *World Development*, 48, 48–70.
- Trani, J. F., Kuhlberg, J., Cannings, T., & Chakkal, D. (2016). Multidimensional poverty in Afghanistan: Who are the poorest of the poor? *Oxford Development Studies*, 44(2), 220–245.
- UN-HABITAT. (2009). *Urban indicators guidelines, "better information, better cities": Monitoring the Habitat agenda and the millennium development goals-slums target*. Kenya: United Nations Centre for Human Settlements.
- UNICEF. (2010). *Water sanitation and hygiene. Technical report*. New York: UNICEF.
- UNICEF. (2012). *Children in an urban world—the state of the world's children*. New York: UNICEF.
- UN. (2015). *Transforming our world: The 2030 agenda for sustainable development*. New York: UNDP.
- UNHROHC. (1989). *Convention on the rights of the child*. Geneva: OHCHR.
- Vaz, A., Oldiges, C., & Alkire, S. (2019). MPI and MODA: Disentangling the differences between a policy tool and advocacy instrument. In Moreno & Zavaleta (Eds.), *Dimensions* (pp. 22–24). Multidimensional Poverty Peer Network (MPPN) no. 7). Oxford: University of Oxford (OPHI).
- Wamani, H., Åström, A. N., Peterson, S., James, K., Tumwine, J. K., & Thorkild, T. (2007). Boys are more stunted than girls in Sub-Saharan Africa: A meta-analysis of 16 demographic and health surveys. *BMC Pediatrics*, 7(17), 1–10.
- WHO & UNICEF. (2010). *The global water supply and sanitation assessment*. Geneva: World Health Organisation Publications.
- WHO Multicentre Growth Reference Study Group. (2006). *WHO child growth standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index: Methods and development*. Geneva: World Health Organisation.
- World Bank. (2015). *Botswana poverty assessment. Report no. 88473-BW*. Gaborone: World Bank.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.