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ABSTRACT

Spatial Differences in Stunting and Household Agricultural Production in South Africa: (Re-)Examining the Links Using National Panel Survey Data*

South Africa is one of only a handful of countries in which the prevalence of child stunting has increased over the period during which progress towards the Millennium Development Goals (MDGs) has been monitored. One explanation for this reversal is that Big Food retail chains have been contributing to a low quality diet across the country, particularly in poor urban households. To examine this claim, we use nationally representative longitudinal data (2008–2014) to trace 6 years of stunting's evolution among South African children and adolescents aged 0–19, with particular attention to how the prevalence of stunting differs between urban (14.9%) and rural (19.6%) areas and how the drivers of poor nutrition vary spatially. The results suggest that, conditional on household income, subsistence farming is associated with a lower probability of stunting. Even more important, although under-nutrition retains a strong spatial component, once observable differences in living standards are controlled for, the higher tendency for children in deep rural households to suffer from (severe) stunting reverses.

JEL Classification: I14, I15, O15, O18, O55

Keywords: stunting, height for age, malnutrition, anthropometric measures, subsistence farming, nutritional inequality, South Africa

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1. Introduction

South Africa is one of only a handful of countries in which the prevalence of child stunting has increased over the period during which progress towards the Millennium Development Goals (MDGs) has been monitored (Hendriks, 2014, Hendriks *et al.*, 2016). Not only does stunting affect about 20% of South African children aged 0–5 (Labadarios *et al.*, 2008), but just over a third of the children who died in the country's hospitals between 2005 and 2009 were severely malnourished (Bamford, 2011). Stunting, which serves as a marker for chronic malnutrition and/or poor maternal health, has a number of long-term impacts on health and may be irreversible in children older than two (Bhutta *et al.*, 2008, Lo *et al.*, 2017).

One of the puzzles in the South African context is that the prevalence of malnourishment and low nutritional diversity has persisted (or even increased) during the expansion of the government's social protection program (from 2002 onwards), which has improved household food security substantially (Hendriks, 2013, Hendriks, 2014, Pienaar and von Fintel, 2014, Ryan and Leibbrandt, 2015, Devereux and Waidler, 2017). This period also coincided with the introduction of the national program for prevention of mother-to-child HIV transmission (Barron *et al.*, 2013), which would have been expected to decrease the prevalence of child stunting (Bailey *et al.*, 1999). Major factors in explaining this persistence despite progress in other developmental indicators and expanded programs to address high levels of HIV infection include low dietary diversity, food insecurity, limited access to agricultural lands, regional food price differentials, and differential access to commercial food retailers. Hence, the South African literature (e.g. Walsh and van Rooyen, 2015) tends to focus on differences in nutritional status between urban and rural regions.

Three positive developments associated with the post-apartheid period – decreasing income poverty (related to an expanded social grant system), declining hunger levels, and improved access to service delivery – have been more pronounced in rural parts of South Africa (Pienaar and von Fintel, 2014, Zimbalist, 2017). Yet the available empirical evidence (Tibesigwa and Visser, 2015, Govender *et al.*, 2017) is mixed in terms of how under-nutrition risk is likely to differ between urban and rural areas and how the drivers of poor nutrition may vary spatially. On the one hand, measures of dietary diversity suggest that households in deep rural areas tend to consume monotonous, low nutrition diets (Schmidt and Vorster, 1995, Labadarios *et al.*, 2011, Govender *et al.*, 2017), with some studies indicating poorer diversity in households farther away from supermarkets (Labadarios *et al.*, 2011). Residents of rural areas also tend to have a lower intake of micronutrients than their urban counterparts (Mchiza *et al.*, 2015). These findings are not necessarily surprising given that rural areas, and particularly those designated

"Black homelands"[1] during the apartheid era, are still defined by high levels of poverty and multiple deprivation (see Noble and Wright, 2013).

On the other hand, an emerging strand of the literature identifies access to Big Food[2] and the higher prices of healthier food items, particularly in poor urban areas, as two of the problems accounting for the rise in non-communicable diseases (NCDs) in South Africa. In fact, a recent comprehensive review of dietary intake (Mchiza *et al.*, 2015) points to evidence of a nutrition transition in the nation, with Black Africans in urban areas, particularly, reporting greater intakes of fat and added sugar. In addition to the well-documented public health challenges of obesity and under-nutrition in South Africa (Igumbor *et al.*, 2012), some research also shows an association between higher income and the ongoing switch to a high fat diet with low nutritional value (MacIntyre *et al.*, 2002). Certain of these trends coincided with a fairly remarkable increase between 2005 and 2010 in the consumption of processed, packaged, and otherwise unhealthy food (Igumbor *et al.*, 2012). This increase has in turn been accompanied by the rapid expansion of large supermarket retailers into all segments of the South African market (D'Haese and van Huylenbroek, 2005, Louw *et al.*, 2007, Igumbor *et al.*, 2012, Kroll, 2016) including rural areas.

It therefore remains unclear whether the increase in child stunting is of greater concern for rural households because they are poorer and have less access to basic services (e.g., clean water and sanitation) and fresh food from large retailers or whether malnutrition may be mitigated in rural areas by lower exposure to Big Food and the nutrition transition's negative aspects, as well as by the ability to improve food diversity through subsistence production. This latter issue of household agricultural production's role in addressing food security and improving nutrition is the subject of some debate in both the broader development and the South African literature. Whereas some work is relatively sceptical of these claims (Sender, 2002, De Swardt, 2003, Bradstock, 2005, Misselhorn, 2005, Palmer and Sender, 2006, Sender, 2012), a handful of studies presents direct evidence of household production's benefits for nutrition in South Africa (Kirsten *et al.*, 1998, Hendriks, 2003, van Averbeke and Khosa, 2007).

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[1] The 1951 Bantu Authorities Act established 10 areas as homelands for South Africa's Black African population. These homelands, now a part of South Africa, are often characterized as "deep rural", with higher levels of subsistence farming than other parts of the country (Noble and Wright, 2013)

[2] This term refers to the large global food and beverage industry and its increasingly concentrated market power and distribution networks (The PLoS Medicine Editors, 2012)

One key gap in the literature, however, is how household production explains some of the spatial differences in child health and nutrition in South Africa. For example, Hendricks et al. (2016: 93), with specific reference to low nutritional levels in rural areas, suggest that "it is not known whether [the nutrition transition leading to stunting and obesity] is exaggerated in poor rural areas, and even less is understood about how infusions of cash in the form of grants and the introduction of other social protection measures interact with subsistence farming to influence household food security strategies and nutrition outcomes". Whereas recent research addresses the issue of household food security strategies (see von Fintel and Pienaar, 2016), no evidence is yet available on nutritional outcomes.

In this paper, we build on the extant literature by using six years of the nationally representative longitudinal South African National Income Dynamics Study (NIDS) to explore the association between child stunting, urban-rural differences, and household agricultural production. The advantage of this data set is that it includes an unusually rich set of socio-economic and demographic variables, which enables us to isolate the associations between child stunting outcomes, spatial variables, and household agricultural activities.

We structure the remaining discussion as follows. Section 2 discusses key nutritional indicators (particularly, child stunting) in South Africa and identifies how these differ across the spatial categories used in national household surveys. Given our focus on agriculture and nutrition in South Africa's rural areas, the section also gives an overview of the spatial trends in poverty, food security, multiple deprivations, and service delivery during the post-apartheid period, as well as commercial retail's growing market penetration over the past decade and its link to poor health outcomes. It concludes by reviewing the international and South African literature on the link between household agricultural production and nutrition. Section 3 then describes the NIDS data and our key analytic variables and outlines our empirical strategy. Section 4 reports the results of two analytic phases; the first, a descriptive analysis of household agricultural production activities and trends in stunting (our key long-term nutrition indicator) by province and area type, and the second, a set of random effects logistic regressions identifying the association between child stunting and household production while controlling for a rich set of socioeconomic and demographic variables. Section five concludes the paper with a discussion of the results.

2. Literature

2.1. Child nutrition

Despite recent progress in poverty reduction and improved food security, child health and malnutrition in South Africa remains a serious concern: although a middle income country, the prevalence of stunting (15.4%) and severe stunting (3.8%) is high (Shisana *et al.*, 2013). Moreover, although it is not uncommon for the prevalence of stunting to improve more slowly than other developmental indicators (e.g., poverty and hunger) in the context of economic growth and rising income levels (World Bank, 2008, Iannotti *et al.*, 2009, Ruel *et al.*, 2013), South Africa is one of just 12 countries worldwide (and the only nation in the Southern African Development Community region) in which this prevalence actually increased[3] in the 2000s (Labadarios *et al.*, 2008, Shisana *et al.*, 2013, Hendriks, 2014, Hendriks *et al.*, 2016).

Patterns of child stunting in South Africa have a strong spatial element, an issue on which we focus in the empirical section of our paper. In general, rates of stunting are highest in rural provinces and in the deep rural areas that have borne the brunt of apartheid era spatial planning in terms of both relative isolation and underdevelopment (Labadarios *et al.*, 2011). The risk of stunting is also subject to gender and spatial differences, with boys from rural informal (non-governmentally planned) areas having a higher risk (23.2%) than boys from urban informal areas (17%) but girls in urban informal areas having the highest stunting prevalence (20.9%) followed by girls in rural informal areas (17%) (Shisana *et al.*, 2013: 206). These data, however, are from the South African National Health and Nutrition Examination Survey whose sample sizes are too small to allow statistical inference. The strongest claim that can be made, therefore, is that both boys and girls from urban formal areas experience significantly lower levels of stunting (Shisana *et al.*, 2013). This conclusion also fits well with the broader South African literature, which suggests that children in deep rural areas are more likely to experience malnutrition and a lack of dietary diversity (see Labadarios *et al.*, 2011).

2.2. The nutrition transition

A different perspective on stunting, and one that has received less attention in the South African literature, involves two related terms: “hidden hunger” and the already referenced “nutrition transition”. Hidden hunger refers to a situation in which food availability is sufficient

[3] Not all studies support this finding (e.g. May and Timaeus, 2014), but a recent review of the evidence for South Africa (Devereux and Waidler, 2017) suggests that, at the very least, there has been no progress in reducing child stunting since 1994 (the first year of democracy).

to prevent hunger (i.e., basic food security needs are met in terms of caloric intake) but food quality is low in terms of micronutrients and dietary diversity. The latter is exemplified by the Bangladesh context in which a rise in stunting prevalence alongside improved food security has probably resulted from persistent hidden hunger caused by poor quality diet and micronutrient deficiencies (Iannotti *et al.*, 2009). Relatedly, the nutrition transition refers to a shift away from traditional foods to the so-called Western diet of "more energy-dense, processed foods, more foods of animal origin, and more added sugar, salt and fat" (Spires *et al.*, 2016: 35). In terms of the link with child stunting, some recent evidence from the Philippines (Puentes *et al.*, 2016) and from Ethiopia and India (Humphries *et al.*, 2017) suggests that the way in which household food expenditure is allocated (i.e. the quality of food purchased) may be more important than the actual amount spent on food.

One of the chief causes of stunted growth in South Africa's children from a nutritional perspective is the low diversity maize-based diet consumed in both rural and poor urban households (Hendriks *et al.*, 2016). An additional aspect is this diet's association with the comorbidity of stunted growth and obesity in children (Hendriks *et al.*, 2016). This association, which is relatively well-documented in the broader literature, is often referred to as the "double burden" of malnutrition (Igumbor *et al.*, 2012, Lipton, 2013). Nonetheless, the evidence on the spatial features of both hidden hunger and the nutrition transition in South Africa remains inconclusive. On the one hand, some studies imply (Igumbor *et al.*, 2012, Battersby and Peyton, 2014) or demonstrate (Igumbor et al., 2012) that the spike in unhealthy and highly processed food consumption is an urban phenomenon, with much of this work suggesting that the food transition and its associated negative outcomes have been concentrated in South Africa's urban areas (Battersby and Peyton, 2014). Igumbor et al. (2012: 6), for example, identify rapid urbanization, concentrated ownership of food production and distribution, and food trade globalization as key contributors to the nutrition transition in South Africa. One important feature of this phenomenon is that healthier food options tend to cost more (as much as 10 to 110 percent more according to some estimates) than unhealthier foods in large commercial supermarket chains (Temple *et al.*, 2011, Igumbor *et al.*, 2012, Battersby and Peyton, 2014, Spires *et al.*, 2016).

On the other hand, some research claims that dietary diversity is far lower in rural provinces and areas (Labadarios *et al.*, 2011), linked partly to an income- monotonous diet association by

which higher income[4] households tend to have more diverse dietary intakes (Labadarios *et al.*, 2011) while rural households are much more likely to be poor (Noble and Wright, 2013, Rogan and Reynolds, 2017). Moreover, although food prices have increased consistently over the past several years (Devereux and Waidler, 2017), they are highest in areas where poor households are located (Labadarios *et al.*, 2011). There is also evidence that, due partly to such government interventions as the subsidization and sometimes VAT exemption of staples like maize and bread, high energy basics are often cheaper than unprocessed foods (including fruits and vegetables) and thus more popular in poorer communities (Mchiza *et al.*, 2015). Hence, contrary to the narrative of the nutrition transition being associated with supermarket purchased foods, other work demonstrates that households situated far away from supermarkets (e.g., those in rural areas) have lower levels of dietary diversity (Labadarios *et al.*, 2011). When households in these rural areas (and to some extent in poor urban areas) do access commercial food retailers, they typically purchase unhealthy food, which may actually accelerate the nutrition transition and contribute to malnutrition through a lack of dietary diversity even in the face of access to supermarkets (Spires *et al.*, 2016).

2.3. Spatial trends in poverty, food security, and multiple deprivations

Not only food consumption and nutrition but also important post-apartheid changes in poverty, food security, and material deprivation exhibit a strong spatial dimension. For example, the well-documented expansion of the government's non-contributory means-tested social grant system (in the form of cash transfers) was more concentrated in rural parts of South Africa. Under this scheme, between 1997 and 2012, the percentage of rural households receiving at least one monthly government cash transfer more than doubled while the percentage of urban grant receiving households increased by only 58 percent (Zimbalist, 2017). Largely as a result of this expansion and extension of the cash transfer program, poverty decreased relatively more in rural areas over the post-apartheid period (Zimbalist, 2017). One key outcome associated with this decrease is the drastic reduction in the percentage of households (both rural and urban) experiencing hunger. Whereas hunger levels have traditionally been higher in rural areas, a sharper reduction in rural areas (the former Black homelands in particular) from the early to mid-2000s, meant that, by 2008, the differences in

[4] Obviously, this relation is not always linear, and there is also evidence that higher income and wealth levels are associated with a high fat, generally unhealthy, so-called modern diet (MacIntyre *et al.*, 2002)

hunger levels between homeland and non-homeland regions had been erased (Pienaar and von Fintel, 2014). Perhaps most significant, a key mechanism for the convergence of hunger levels across these area types has been the facilitation of household agricultural production by the expansion of cash transfers (von Fintel and Pienaar, 2016).

In addition to the reduction of income poverty and hunger, one of the most marked improvements in rural (relative to urban) areas has been the rapid increase in access to clean (piped) water, electricity, and telephones. Increases in access to these basic services have been far more substantial in rural areas (more than doubling in the case of electricity and telephone) than in urban areas where improvements have been more measured and from a much higher base (see Zimbalist, 2017). Yet despite this encouraging progress, the rural former homelands remain far poorer and suffer from a significantly higher level of multiple deprivations (including income, employment, education, living conditions, and health) relative to the rest of South Africa (Noble and Wright, 2013). In short, the spatial legacy of apartheid remains intact despite some important progress in service delivery and the injection of cash transfers into rural households (Noble and Wright, 2013, Pienaar and von Fintel, 2014).

2.4. Household agricultural production and nutrition

Given the progress in rural South Africa in poverty reduction and improved food security together with the potential role of household agricultural production (Pienaar and von Fintel, 2014, Rogan and Reynolds, 2017), the link between agriculture and nutrition is a natural focus in the context of high levels of child stunting. Nevertheless, internationally, the evidence on the impact of either household or small-scale subsistence agricultural production (Berti et al., 2004) or agricultural interventions (Berti *et al.*, 2004) on child and maternal nutrition is inconclusive, making both the subject of long-time debate (Lunven, 1982, von Braun and Kennedy, 1986, Ellis, 1998, Smitasiri, 2001, Ramı´rez, 2002). Even in studies that do identify an association between subsistence agriculture and child anthropometry, the effects tend to be quite small (Ruel *et al.*, 2013). Hence, in general, although the literature (Ruel, 2001, World Bank, 2008, Pinstrup-Andersen, 2013, Ruel *et al.*, 2013) outlines a clear conceptual link between household agriculture and nutrition, establishing an empirical association between household production activities or interventions and nutrition remains elusive (Carletto *et al.*, 2015).

Naturally, there are exceptions, although three of the most comprehensive studies showing an empirical link between household agricultural production and nutrition are by no means recent. For example, Shack et al. (1990), in their now seminal work on household agriculture and nutrition in Papua New Guinea, show that cash crop income allows households to

supplement traditional diets with energy- and protein-dense purchased foods, which has a positive impact on child nutrition. Likewise, some of the more detailed empirical work demonstrating the link between subsistence agriculture and child nutrition, again in Papua New Guinea, associates both more intense and diverse small-scale agricultural activities and household income with improved child nutrition (Mueller et al., 2001a, 2001b). More recent evidence of a positive impact on nutrition comes from evaluations of a homestead agricultural support package in Bangladesh (Iannotti *et al.*, 2009) and an agricultural and nutritional project in Mozambique (de Brauw *et al.*, 2015). Recent work, including several studies published in a special issue of this journal (Carletto *et al.*, 2015), has, moreover, demonstrated partial evidence for the protective effect of livestock ownership and crop production (Slavchevska, 2015) and production diversity (Kumar *et al.*, 2015) on child stunting. Across these studies, however, the results are mixed in terms of which types of production impact on nutrition and on which age groups (see, for example, Shively and Sununtnasuk, 2015).

South Africa, as a middle-income country, has relatively lower levels of subsistence agriculture than many of the developing countries addressed in the literature. The empirical base for South Africa is also thin, with only a handful of studies attempting to demonstrate a link between household production and nutrition[5]. Perhaps the most detailed of these (Kirsten *et al.*, 1998) is not only from two decades ago but is based on only a small number of households (79) in one province. This research does, however, provide evidence that household agricultural production improves nutrition but only in households for which agriculture is a serious activity, which implies that community gardens and purely subsistence agricultural activities are not linked to improved nutrition (see also Hendriks, 2003). Such a conclusion inherently obscures the possibility of a dual causality in which some of the more successful households at farming may also have higher levels of nutrition and a more diverse diet.

Other work from South Africa, although more recent, is based on samples that are not only small but very narrow in geographic focus (Hendriks, 2003, Modi *et al.*, 2006, van Averbeke and Khosa, 2007, Adekunle *et al.*, 2014). The most recent (Hendriks et al. 2016) does provide some evidence that household production is associated with greater dietary diversity, but the bivariate analysis (again based on a small sample size) is methodologically weak. Nonetheless, the empirical work for South Africa, although limited, does provide some indication that

[5] The empirical basis for the association between household production and food security (Aliber and Hart, 2009, Pienaar and von Fintel, 2014, Devereux and Waidler, 2017, Rogan and Reynolds, 2017) is much stronger.

subsistence agriculture is associated either directly or indirectly with a higher intake of nutrient dense foods when households produce these foods themselves or grow staples and then redirect household resources towards the purchase of animal products and fresh fruit and vegetables (Schmidt and Vorster, 1995, van Averbeke and Khosa, 2007, Govender *et al.*, 2017). To date, however, there is no analysis of the link between child stunting (or the broader issue of nutrition) and household production based on a large scale nationally representative survey. As a result, the relative risks (and determinants) of malnutrition in urban and rural areas remain largely unexplored.

3. Methodology

3.1. Data

Our dataset comprises the first four waves of South Africa's first nationally representative panel survey (SALDRU, 2016d, SALDRU, 2016c, SALDRU, 2016b, SALDRU, 2016a), the South African National Income Dynamics Study (NIDS).[6] The initial wave (2008) was administered to about 28,000 individuals in 7,300 households, designated as continuing sample members (CSM), a group that includes children born or adopted into the original survey households. In the subsequent waves, administered every two years, new individuals entered the survey if and only if they were co-residing with an original CSM and were therefore labelled temporary sample members (TSM). Because NIDS is designed to follow CSMs and their co-residents during the time of cohabitation, the sample size increases over time, to around 34,000, 37,000, and 42,000 individuals in waves 2, 3, and 4, respectively.

3.2. Sample

There is a growing body of literature within nutritional sciences which suggests that the vast majority of growth faltering occurs in utero and/or in the first 24 months of life, and may be irreversible later in life (Shrimpton *et al.*, 2001, Victora *et al.*, 2010, Black *et al.*, 2013). In contrast to this commonly established view, other studies, however, show that height catch-up can occur at later stages in life. For example, Prentice *et al.* (2013) identify particular potential for substantial height catch-up even in the absence of interventions between 24 months and mid-childhood and again between mid-childhood and adulthood. Using longitudinal data from rural Gambia, Prentice et al. show that there is a prolonged growth to the age of 22-24 and 18-19 years among boys and girls, respectively. Similarly, an extended pubertal growth phase

[6] For more information on the NIDS, see Chinhema *et al.* (2016)

which allows for substantial height recovery is also found in rural Tanzanian (Hirvonen, 2010) and Senegalese (Coly *et al.*, 2006) populations. Therefore, it is of paramount importance to challenge the common impression that interventions outside the first 1000 days window, i.e. from conception to the age of 24 months cannot be effective (Hirvonen, 2010, Prentice *et al.*, 2013).

Thus, for our analysis, we use the full age range for which height for age *z*-scores, the central measure for our study, are available. The NIDS provides height for age *z*-scores for children, adolescents, and young adults aged 0 to 19 years with initial samples of 9,321, 8,485, 12,635, and 15,384 individuals in waves 1, 2, 3, and 4, respectively. However, where indicated, we also test the sensitivity of our results to narrower age group ranges.

3.3. Anthropometric measurement of stunting

With the assistance of a qualified nurse, fieldworkers received training on how to measure height and other anthropometric factors, including how to measure babies' and young children's (< 24 months) height in the recumbent position. Two height measurements were taken and averaged, and if these differed by more than one centimetre, a third measure was taken to calculate the height for age *z*-scores. These latter were based on age in days and on the WHO international child growth standards (WHO, 2006) for children aged 5 and younger and the WHO standards for children and adolescents (De Onis *et al.*, 2007) for individuals over 5. (Severe) stunting was defined as (3) 2 standard deviations below the growth standard median, with *z*-scores of >6 and <-6 considered biologically implausible and excluded from the analysis. Our dependent variable is thus binary (yes/ no), indicating whether a respondent is or is not (severely) stunted.

3.4. Explanatory variables

One of our main explanatory variables is aggregated household income, used to reflect a household's regular monthly income net of taxes. The derived income variable is an aggregate of different income sources, including labour market income; government grants and other government payments (e.g., unemployment insurance fund, workmen`s compensation); interest, dividend, and rental income; remittances; subsistence agriculture; and imputed rental income from owner-occupied houses. Total household income is deflated using the monthly national headline consumer price index with November 2014 as the base month (*Statistics South Africa*, 2017). Lastly, we construct the natural logarithm of real equivalized net household

income, adjusted to household structure using the modified OECD scale (Hagenaars *et al.*, 1994).

Our main variable of interest is a dummy variable indicating whether a household is engaged in farming activities that are not part of paid employment, such as growing food or raising livestock. Also important is geographic classification of residence, provided in NIDS based on the 2011 census (SALDRU, 2014), which also describes infrastructure, level of service delivery, and market access, as well as density of and distance to hospitals and doctors. We therefore include a set of dummy variables for whether the respondent lives in a traditional, farming, or urban area (reference category). Whereas traditional areas are closely associated with the Black homelands of the apartheid era and remain under the jurisdiction of traditional leaders (see Noble and Wright, 2013), urban settlements are continuously built-up areas such as cities, towns, townships, small towns, and hamlets. Farming areas are locations in which land is allocated and used for commercial farming.

In addition to household income, we also control for several socio-economic and socio-demographic variables at the individual and household level, including gender, population group, gender and educational level of household head, and number of employed persons in the household. We also control at the household level for living conditions that might directly affect respondent and child health, including diarrheal diseases caused by inadequate access to water and sanitation (Prüss-Ustün *et al.*, 2014). The model thus includes variables for whether the respondent lives in a household with access to a flush toilet, tap water, electricity, and whether refuse and rubbish are removed on a regular basis.

3.5. Econometric analysis

Our binary dependent variable requires a non-linear probability model, which can also account for the longitudinality of the data. At the same time, our interest in multiple time-constant explanatory variables (e.g., population group and gender) precludes the use of a fixed-effects (FE) logistic estimator. Thus, we estimate random effects logistic regressions that allow inclusion of both time-variant and time-constant variables. These regressions also allow for unobserved heterogeneity but with the stronger assumption of no correlation with our explanatory variables. Our random effects logistic regression model can thus be formulated as

$$ln\left(\frac{\Pr(y_{it}|\,\beta, x_{it}, \gamma, z_i, \theta_t, u_i)}{1 - \Pr(y_{it}|\,\beta, x_{it}, \gamma, z_i, \theta_t, u_i)}\right) = \beta_0 + \beta\, x_{it} + \gamma\, z_i + \theta_t + u_i$$

where x_{it} is the time-variant and z_i the time-constant explanatory variables, θ_t denotes a set of survey year indicators, and u_i is the unit-specific error term. Unlike panel estimators for continuous dependent variables, binary response models focus on probabilities; they are thus inherently stochastic and seldom contain an idiosyncratic error (ε_{it}) that varies over time (Andreß *et al.*, 2013).

4. Results

One important initial insight from the weighted descriptive statistics for the prevalence of (severe) stunting (both pooled sample and disaggregated by survey year and province) is that the nationwide prevalence decreased substantially from 17% in 2008 to 12% in 2014 but increased to about 20% in both 2010 and 2012 (see Table 1). The table also reveals substantial differences in both levels and trends of stunting across provinces. Although in most provinces the prevalence of (severe) stunting decreased between 2008 and 2014, it remained at high levels in the largely rural provinces of the Northern and Eastern Cape, the Free State, and the North West, with an actual increase in these latter two. Although the 2008–2012 increases in both stunting and severe stunting conform closely to the findings from key studies on nutrition in South Africa, the noticeable decrease in 2014 is something of an anomaly.[7]

Focusing on the descriptive trends in the 2008–2012 period, the relative increases in stunting and severe stunting are similar in both the deep rural (traditional) and urban areas at 16 and 19 percent, and 35 and 36 percent, respectively. These increases, however, grew from a much higher base in the traditional areas. The table also suggests that the convergence in the prevalence of malnutrition (proxied by stunting) between rural and urban areas did not occur in the same way as the well-documented convergence in hunger levels.

Table 1 about here

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[7] This anomaly is not necessarily a problem for our empirical strategy because we are interested in the relation between subsistence agriculture and stunting. We do note, however, that there are several plausible explanations for the relatively rapid decrease in stunting prevalence between the last two waves of NIDS. First, the outcomes could reflect survey attrition which, if correlated with stunting risk itself, would not be corrected by the post-stratification survey weights. Second, the decrease could also reflect delayed reaction to the social grant expansion and corresponding decreases in hunger levels. It is likely, for example, that a number of CSMs from the panel survey moved out of the 0–19 cohort during the 2014 wave and did not benefit from the expanded social protection system at ages 0–5. They were thus more likely to be at risk for malnutrition and hunger at crucial stages in their development.

The weighted descriptive statistics for all analytic covariates over the six-year time span further reveal a slight increase in real equivalized household income, from about R3,400 in 2008 to R3,900 in 2014 (see Table 2). The share of the population involved in subsistence farming decreased substantially (24% in 2008) in the two waves subsequent to the initial wave (11% and 10%) and then increased again (17%) in 2014. At the same time, the geographic classification reflects a migration tendency from traditional and farming areas to the cities. For example, in 2008, the fraction of the sample living in traditional (urban) areas was 44% (51%), which decreased (increased) to 41% (56%) in 2014. Focusing specifically on changes over the six-year time span further reveals improved educational levels, with a decreasing share of household heads who have no or only some primary schooling and an increased enrolment in secondary schooling and higher education. At the same time, in line with the well-documented expansion of basic services over the 2008–2014 period, we also note improved living conditions in terms of access to tap water, a flush toilet, electricity, and a waste disposal system. Nonetheless, the average number of employed persons in the household increased only marginally, reflecting the persistently high levels of unemployment and large dependency on social grants in the country.

Table 2 about here

For the multivariate random effects logistic regression models, we run two different specifications for each stunting measure (Table 3)[8]. For specifications 1 and 2 (stunting), the coefficients on household income are significant and negative, supporting the expectation that higher income will be associated with a lower probability of stunting. That is, although it remains unclear whether and to what extent higher income leads to healthier and higher priced food choices, income is the main determinant of access to food and a greater variety of food choices. As regards the variable of most interest to this study, involvement in subsistence farming, we again find a significantly negative impact on the probability of stunting, which supports the intuitive assumption that agricultural involvement improves access to food by providing an additional food source. At the same time, although it is less clear whether and to what extent subsistence farming may lead to greater dietary diversity, the negative association

[8] The results reported hereafter are largely consistent when we restrict the analysis to individuals aged 0-14 years or sub-divide the analysis into smaller groups of individuals aged 0-5, 6-10, 11-15, and 16-19.

between subsistence farming and stunting probability could indicate a diet that is, to a lesser degree, based on either packaged or processed food or a monotonous diet devoid of fresh food.

Given that deep rural traditional areas are associated with high levels of poverty, unemployment, and material deprivation, it is not surprising that we initially find a positive and significant coefficient for specification 1; that is, a higher probability of stunting in traditional areas even after income is controlled for. Once we add in controls for living conditions (specification 2), however, the direction of the association reverses while still remaining significant. In other words, once we control for the detrimental effects of poor living conditions, living in traditional areas poses a significantly lower risk of stunting. Most important, the size and direction of the association between subsistence farming and stunting remains the same in the second specification. Thus, once income, living conditions, and a large set of covariates are controlled for, involvement in agricultural activities for household consumption is a significant protector against stunting. Taken together, these results are consistent with the hypothesis that rural households may be less exposed to the nutrition transition and the negative aspects of Big Food. They may even be able to enhance their dietary diversity through access to wild food.

The analytic results further suggest that females are less likely to be stunted whereas gender of the household head appears to have no statistically significant effect. As regards population groups, Whites have a significantly lower probability of being stunted than Black Africans (reference group), Coloureds are significantly more likely to be stunted, while Indians/Asians exhibit a non-significant negative effect. The probability of stunting also decreases with education level, significantly so for a household head with some type of secondary schooling or higher education compared to the no schooling reference but only insignificantly for primary schooling.

In the case of severe stunting (specifications 3 and 4), for most control variables, the direction and size of the estimated coefficients are very similar to those using (non-severe) stunting as the dependent variable (see Table 3). However, certain confounding variables – such as living in a traditional or farming area, having secondary schooling, or having access to a flush toilet – are not significant in specification 4. In both specifications, being White has a positive but insignificant coefficient. It is also important to note that rho – the total error variance due to unobserved heterogeneity – is much lower in the severe stunting specifications than in those for (non-severe) stunting (about 38% vs. 53%). Rho can also be interpreted as the serial correlation that remains in the dependent variable after all explanatory variables are controlled for because of person-specific unobserved heterogeneity (Andreß, Golsch, and Schmidt, 2013: 241). More broadly, however, the key finding from the stunting specifications

is also observable in the severe stunting specifications: once living conditions (i.e., access to basic services) are controlled for, the higher risk of severe stunting in deep rural traditional areas disappears. At the same time, the apparent protective effect of subsistence agriculture remains in both severe stunting specifications.

Table 3 about here

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5. Discussion and Conclusions

Not only is stunting endemic in South Africa but there is sparse evidence of any improvement over the past 20 years. This lack of progress is particularly worrying given that South Africa, as a middle-income country, has made important strides over recent years in service delivery, access to clean water, expansion of social security protection, and reduction of hunger levels. South Africa even ranks highest on the Hunger and Nutrition Commitment Index Africa[9] for its efforts to combat food insecurity and undernutrition. Why then has stunting persisted and possibly even worsened despite these efforts and widespread recognition of the condition's long-term developmental impacts (Duc and Behrman, 2017, Lo *et al.*, 2017)?

Some of the more recent contributions to the South African literature argue that the problem is not simply the lack of food associated with stunting and other forms of malnutrition or undernourishment but rather the quality of the food available to households in poor areas (both urban and rural). This work is particularly interested in the role of Big Food in creating a food system in South Africa that offers poorer households affordable food products with very little nutritional value (Igumbor *et al.*, 2012, Ledger, 2016). To date, however, the empirical evidence for these claims remains both thin and inclusive given some research claims that access to large supermarket chains protects against under-nutrition by improving dietary diversity.

This paper adds to the literature by exploring the prevalence of stunting through the lens of spatial differences and subsistence agriculture, both of which we propose as crude proxies for the level of interaction with large supermarket retailers. Our key finding is that once household income and a range of other covariates are controlled for, children, adolescents, and young adults in households that engage in subsistence agriculture are significantly less likely to suffer from stunting or severe stunting. Although only suggestive, these findings are consistent with

[9] http://africa.hancindex.org/

the argument that households that purchase their food from large retailers are more likely to experience the negative effects of the nutrition transition.

Nevertheless, even after multiple factors are controlled for, the risk of stunting remains higher in deep rural areas – particularly those demarcated as Black homelands under apartheid. In fact, it is only when we control for access to basic services like sanitation and piped water that the higher risk of stunting in rural areas reverses (cf. May and Timaeus, 2014, Hammer and Spears, 2016, Mulmi *et al.*, 2016, Vyas *et al.*, 2016, Devereux and Waidler, 2017). This finding is crucial in its implication that once we control for the more obvious and observable sources of deprivation for rural households, children in these households are actually at a significantly lower risk of stunting than their urban counterparts.

In terms of our contribution to the larger body of international literature on small-scale agriculture, we claim merely that our findings suggest ways in which households disconnected from the Big Food system in South Africa may be partially protected from reliance on the empty high energy calorie foods that are generally affordable (see Ledger, 2016). Hence, while careful not to promote an over-romanticized notion that subsistence agriculture or home gardening is the solution to undernutrition and its effects in South Africa, we cannot ignore the possibility that such activities could play into this solution. Unfortunately, as yet, South Africa has no formal food security policy, with any legislative mention tending to be abstract and disjointed (Hendriks, 2014) and related policy to date being somewhat fragmented, with interventions falling across sectors from education (in the form of school feeding schemes) to social development to agriculture. Policy also tends to frame nutrition as a "rural and food production issue" (Hendriks, 2014, Spires *et al.*, 2016: 38) even though a subsistence farming solution places the responsibility for nutrition largely on poor rural households while detracting from larger development and public health issues. Not only have no attempts yet been made to formally evaluate the existing food programs, but interventions frequently fail to differentiate between the indicators of nutrition and those of basic hunger. For example, whereas cash transfers play a large role in improving food security in South Africa ((see Devereux and Waidler, 2017), their monetary amounts are likely to be too small (and decreasing in real terms) to significantly improve dietary quality.

Hence, even though policies that make land available for small scale food production in South Africa certainly have their proponents (Labadarios *et al.*, 2011), our findings are only broadly supportive of such an approach. In fact, despite pointing to the important role of subsistence agriculture, our analysis identifies several other factors capable of explaining urban and rural area differences. One such difference is the likelihood of both stunting and severe

stunting being higher in deep rural areas, a tendency that holds in our descriptive statistics but reverses when our regressions control for the multiple deprivations of income, education, and access to basic services. This observation is crucial because it implies a negative association between stunting risk and living in households located farther away from retail supermarket chains. Thus, rather than supporting the controversial idea of home gardens and similar subsistence activities as a policy solution to hunger and malnutrition, our results suggest that these activities may serve as a proxy for disconnection from a Big Food system that is actually quite harmful for poorer households.

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Table 1 Stunting (%) by province/area and year

Stunting	**All waves**	**2008**	**2010**	**2012**	**2014**
All Provinces	17.1	16.7	20.7	19.9	12.4
Western Cape	11.5	13.1	15.0	12.7	7.8
Eastern Cape	21.0	25.8	26.1	20.3	14.8
Northern Cape	20.1	22.5	18.6	21.4	18.2
Free State	18.3	16.6	19.6	19.5	17.1
KwaZulu-Natal	18.3	16.5	23.3	20.4	13.8
North West	17.0	13.1	17.5	20.6	16.3
Gauteng	14.5	13.9	16.4	18.5	9.8
Mpumalanga	15.6	13.3	16.4	23.2	9.4
Limpopo	19.1	15.9	24.2	23.5	13.3
Traditional	19.8	18.9	24.0	23.0	14.3
Urban	14.9	14.6	17.6	17.7	11.0
Farms	17.6	19.8	21.1	15.8	14.1
Severe stunting					
All Provinces	5.5	6.0	6.7	7.3	2.6
Western Cape	2.3	2.6	3.3	2.5	1.5
Eastern Cape	8.8	14.7	10.1	9.1	3.4
Northern Cape	5.1	4.8	5.4	6.3	4.1
Free State	3.6	2.1	5.1	4.6	2.6
KwaZulu-Natal	6.1	4.7	9.1	7.9	3.0
North West	5.0	3.0	6.1	8.9	2.4
Gauteng	4.2	4.9	3.7	6.7	1.8
Mpumalanga	5.5	5.2	4.4	9.9	2.1
Limpopo	5.7	5.5	6.9	7.3	3.6
Traditional	6.6	7.0	7.9	8.9	3.2
Urban	4.4	4.8	5.5	6.0	2.2
Farms	6.9	9.9	7.6	7.6	2.8

Note: National Income Dynamics Study (NIDS) data for participants aged 0-19 years weighted using post-stratification weights.

Table 2 Descriptive statistics: Means and standard deviations, weighted

	All waves		Wave 1		Wave 2		Wave 3		Wave 4	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stunting (yes/no)	0.171	0.38	0.167	0.37	0.207	0.40	0.199	0.40	0.124	0.33
Severe stunting (yes/no)	0.055	0.23	0.060	0.24	0.067	0.25	0.073	0.26	0.026	0.16
Equivalized HH income	3113.908	6106.06	2391.377	5059.68	2584.396	4788.17	3187.563	6094.56	3898.244	7346.44
Real equivalized HH income	3569.452	6865.34	3395.046	7015.40	3242.931	6012.56	3618.760	6921.25	3862.957	7225.34
Ln real equivalized HH income	7.546	1.02	7.402	1.08	7.393	1.06	7.578	0.99	7.717	0.95
Subsistence farming (yes; ref.: no)	0.154	0.36	0.242	0.43	0.108	0.31	0.103	0.30	0.173	0.38
Geographic classification:										
Traditional	0.430	0.50	0.446	0.50	0.456	0.50	0.424	0.49	0.408	0.49
Urban	0.532	0.50	0.512	0.50	0.499	0.50	0.542	0.50	0.559	0.50
Farming	0.038	0.19	0.042	0.20	0.045	0.21	0.034	0.18	0.033	0.18
Female	0.503	0.50	0.502	0.50	0.510	0.50	0.499	0.50	0.501	0.50
HH head is female	0.640	0.48	0.525	0.50	0.628	0.48	0.729	0.44	0.643	0.48
HH head educational level										
No schooling	0.169	0.37	0.212	0.41	0.213	0.41	0.149	0.36	0.127	0.33
Primary school	0.265	0.44	0.313	0.46	0.283	0.45	0.231	0.42	0.250	0.43
Secondary school	0.429	0.49	0.370	0.48	0.397	0.49	0.476	0.50	0.446	0.50
Higher education	0.138	0.34	0.104	0.31	0.106	0.31	0.144	0.35	0.177	0.38
Number of employed persons in HH	1.058	1.04	1.002	1.01	0.916	0.98	1.068	1.06	1.184	1.07
Access to flush toilet	0.494	0.50	0.449	0.50	0.481	0.50	0.511	0.50	0.517	0.50
Access to tap water	0.879	0.33	0.856	0.35	0.888	0.32	0.889	0.31	0.880	0.32
Removal of refuse and rubbish	0.499	0.50	0.471	0.50	0.462	0.50	0.515	0.50	0.530	0.50
HH has electricity	0.831	0.37	0.791	0.41	0.769	0.42	0.857	0.35	0.876	0.33
Race (ref.: Black)	0.857	0.35	0.856	0.35	0.864	0.34	0.861	0.35	0.850	0.36
Coloured	0.076	0.27	0.075	0.26	0.073	0.26	0.075	0.26	0.080	0.27
Indian/Asian	0.018	0.13	0.020	0.14	0.017	0.13	0.016	0.12	0.019	0.14
White	0.049	0.22	0.049	0.22	0.046	0.21	0.048	0.21	0.051	0.22
Wave 1	0.208	0.41	1.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
Wave 2	0.204	0.40	0.000	0.00	1.000	0.00	0.000	0.00	0.000	0.00

Wave 3	0.286	0.45	0.000	0.00	0.000	0.00	1.000	0.00	0.000	0.00
Wave 4	0.302	0.46	0.000	0.00	0.000	0.00	0.000	0.00	1.000	0.00
Western Cape	0.084	0.28	0.066	0.25	0.077	0.27	0.090	0.29	0.095	0.29
Eastern Cape	0.146	0.35	0.150	0.36	0.151	0.36	0.141	0.35	0.145	0.35
Northern Cape	0.022	0.15	0.022	0.15	0.018	0.13	0.023	0.15	0.023	0.15
Free State	0.052	0.22	0.051	0.22	0.050	0.22	0.055	0.23	0.050	0.22
KwaZulu-Natal	0.231	0.42	0.243	0.43	0.255	0.44	0.219	0.41	0.216	0.41
North West	0.053	0.22	0.059	0.23	0.051	0.22	0.050	0.22	0.053	0.22
Gauteng	0.212	0.41	0.210	0.41	0.201	0.40	0.215	0.41	0.219	0.41
Mpumalanga	0.089	0.29	0.089	0.29	0.082	0.27	0.093	0.29	0.090	0.29
Limpopo	0.112	0.31	0.111	0.31	0.114	0.32	0.114	0.32	0.108	0.31
Number of observations	43,314		7,986		8,256		12,335		14,737	

Note: National Income Dynamics Study (NIDS) data for participants aged 0-19 years weighted using post-stratification weights.

Table 3 Random effects logistic regression estimates on (severe) stunting: NIDS (2008-2014)

	Stunting				Severe stunting			
	(1)		(2)		(3)		(4)	
	Coef	*SE*	*Coef*	*SE*	*Coef*	*SE*	*Coef*	*SE*
Ln real equivalized HH income	-0.229***	0.027	-0.202***	0.028	-0.169***	0.036	-0.136***	0.037
Subsistence farming (yes; ref.: no)	-0.178***	0.048	-0.200***	0.049	-0.347***	0.069	-0.365***	0.070
Geographic classification (ref.: urban)								
Traditional	0.157***	0.060	-0.161**	0.081	0.136*	0.073	-0.116	0.103
Farming	0.071	0.096	-0.204*	0.106	0.121	0.118	-0.141	0.134
Population group (ref.: African)								
Coloured	0.337***	0.098	0.388***	0.099	0.274**	0.123	0.293**	0.124
Indian /Asian	-0.327	0.303	-0.159	0.304	-0.692	0.436	-0.557	0.435
White	-0.561**	0.254	-0.521**	0.254	0.121	0.302	0.105	0.303
Female	-0.451***	0.043	-0.449***	0.044	-0.371***	0.052	-0.371***	0.053
HH head is female	-0.048	0.041	-0.041	0.041	0.036	0.055	0.053	0.056
HH head educational level (ref.: no schooling)								
Primary school	-0.062	0.053	-0.038	0.053	0.016	0.066	0.047	0.067
Secondary school	-0.198***	0.053	-0.162***	0.054	-0.151**	0.068	-0.108	0.069
Higher education	-0.379***	0.084	-0.334***	0.085	-0.335***	0.117	-0.294**	0.118
Number of employed persons in HH	0.022	0.021	0.018	0.022	0.023	0.029	0.020	0.029
Access to flush toilet			-0.325***	0.071			-0.103	0.094
Access to tap water			-0.194***	0.054			-0.276***	0.069
Removal of refuse and rubbish			-0.063	0.068			-0.112	0.094
HH has electricity			-0.190***	0.050			-0.275***	0.063
Constant	-0.571**	0.228	-0.098	0.238	-2.529***	0.304	-2.079***	0.315
/lnsig2u	1.295***	0.046	1.298***	0.046	0.695***	0.092	0.702***	0.093
Number of observations		43,810		43,314		43,810		43,314
Number of groups		22,328		22,226		22,328		22,226
Rho		0.526		0.527		0.378		0.380
sigma_u		1.911		1.914		1.415		1.420
Chi^2		759.172		804.423		505.601		540.345

Note: Regressions include survey year indicators and dummy variables at the province level. *** p<0.01, ** p<0.05, * p<0.1.