



Investigating tangible and mental resources as predictors of perceived household food insecurity during pregnancy among women in a South African birth cohort study



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ABSTRACT

Rationale: Food insecurity during pregnancy is concerning given the increased nutritional needs of the mother for proper fetal development. However, research is lacking within the South African context to investigate the association of economic and psychosocial factors and food insecurity among pregnant women, using comprehensive, conceptually driven models.

Objective: This study applies the Network-Individual-Resource (NIR) Model to investigate individual, intimate dyadic, and family level predictors of perceived household food insecurity for pregnant women. **Methods:** 826 pregnant women enrolled in the Drakenstein Child Health Study (DCHS), a birth cohort in two communities in a peri-urban area of South Africa. Hierarchical logistic regressions were used to investigate the impact of household/family, intimate dyads, and individual tangible and mental resources on perceived household food insecurity during the critical period of pregnancy. Perceived household food insecurity was assessed through an adapted version of the USDA Household Food Security Scale – Short Form.

Results: Among 826 pregnant women in South Africa, individual-level tangible resources (e.g. income, social assistance, HIV status) and mental resources (e.g. depression, childhood trauma) predicted perceived household food insecurity and these predictors differed by community. Intimate dyadic and family level resources did not predict household food insecurity.

Conclusions: Our findings of the economic and psychosocial predictors of perceived household food insecurity among pregnant women in South Africa, mirror findings in general populations. This study provides support for the extension of the NIR model to perceived household food insecurity, particularly regarding individual-level mental and tangible resources, as well as the impact of community-level factors. Future research should investigate the extent to which resource sharing occurs within networks.

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Food insecurity during pregnancy a concern for both maternal and fetal health. There are increased nutritional needs of the mother for proper fetal development (Ivers and Cullen, 2011), which, if not met, can increase the risk of low birth weight (Borders

et al., 2007) and risk of birth defects such as spina bifida (Carmichael et al., 2007). Additionally, malnutrition among women has also been associated with iron deficiency anemia, a major cause of maternal mortality (Darnton-Hill and Coyne, 1998). Although there is an established literature on the determinants of food insecurity among general populations (Gundersen, 2013; Gundersen et al., 2011), the literature is lacking with regards to socio-demographic and psychological predictors of food insecurity during pregnancy, particularly in low and middle income countries

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(LMIC; Ivers and Cullen, 2011).

In southern Africa, the food insecurity literature has largely been focused on economic and environmental stressors with regards to maternal nutrition (Misselhorn, 2005; Salam et al., 2015; Weaver and Hadley, 2009). However, psychological factors can also play a role in an individual's ability to procure food (Misselhorn, 2005). For example, depressive symptoms, anxiety, and greater perceived stress have all been associated with food insecurity among pregnant women and mothers in high income countries (Laraia et al., 2006; Whitaker et al., 2006). However, research is lacking within the South African context to investigate the association of psychosocial factors and food insecurity among pregnant women. Furthermore, previous literature lacks a comprehensive focus on the multiple levels of factors that can impact food insecurity among pregnant women through a theoretical lens. This is particularly true in low and middle income countries (LMIC), where food insecurity is often more extreme and where large portions of the populations may face a wider range of environmental, structural, family, and individual risk factors for food insecurity (Grobler, 2016). A meta-analysis of food insecurity factors in southern Africa found that poverty, environmental stressors, and conflict accounted for 50% of the drivers of food insecurity (Misselhorn, 2005).

We propose using the Network-Individual Resource (NIR; Johnson et al., 2010) model to examine predictors of food insecurity comprehensively among pregnant women in South Africa, a key population for public health impact. The NIR model was first developed within the HIV prevention literature to address how both personal risk and prevention efforts depend on the resource needs of individuals being met and how these resources are shared within networks (Johnson et al., 2010). It has since been used to discuss a variety of health behaviors (Johnson and Michie, 2015) including college drinking (Reid et al., 2015), family planning (Mohan and Shellard, 2014), and the impact of social stigma on population health (Cook et al., 2014). The NIR model proposes that there are two categories of resources, mental and tangible, and these resources operate at the individual level and the network levels (intimate dyad, family, peers/community, and/or society). Additionally, resources are necessary for the individual to “survive and thrive” and individuals and networks most value the resources that satisfy their most pressing needs. Furthermore, networks serve as resources for individuals, who, in turn, are resources for the networks to which they belong (Johnson et al., 2010).

With regard to household food insecurity, we can consider influential factors at three levels, individual (the pregnant woman), intimate dyadic (the partnership between the pregnant woman and their significant other) and at the family level. At the individual-level, some pregnant women may have their own personal income to assist with obtaining food for their household, thereby reducing household food insecurity (Schmeer et al., 2015). Additionally, programs that provide financial assistance for things other than food such as care for disabled dependents can take strain off finances that can be re-appropriated towards the costs of acquiring food (Ivers and Cullen, 2011). Also, according to the NIR model, physical health is a tangible resource. South Africa has the largest HIV epidemic in the world (UNAIDS, 2015) and previous research has established multiple links between food insecurity and HIV acquisition risk and HIV morbidity and mortality through nutritional, mental health, and behavioral pathways (Weiser et al., 2011). At the individual-level there are also many mental resources, or psychosocial factors, which can bolster or impede perceived household food insecurity. For example, depression may impact a pregnant woman's motivational and/or cognitive abilities to obtain food on a regular basis (Hernandez et al., 2014; Melchior et al., 2009). Depression may also impact a pregnant woman's work productivity and, in turn, her wages (Stewart et al., 2003). Although

less research has been conducted investigating the impact of stressful life events and psychological distress on perceived household food insecurity, one can hypothesize that the process may be similar to depression and perceived household food insecurity (Becerra et al., 2015; Jebena et al., 2015). Childhood trauma has also been shown to negatively impact a pregnant woman's ability to procure food because of its lifelong income consequences caused by poor schooling and job performance (Chilton et al., 2015) as well as also being a significant risk factor for mental disorders in adulthood (Norman et al., 2012). Depression, childhood trauma, stressful life events, and psychological distress all undermine overall mental health and can impact perceived control over current circumstances and skills to address household food insecurity.

There are also resources that operate at the family level that can influence perceived household food insecurity. For instance, household income would be a tangible resource that operates at the family level, which can influence perceived household food insecurity (Loopstra and Tarasuk, 2013). While household income includes individual-level incomes, it also takes into account the family context of resource sharing, which is particularly true in South Africa. Many pregnant women also have another important source of tangible and mental resources: their intimate partner, such as in a marriage or marriage-like relationship (Zwang and Garenne, 2008). In this “intimate dyadic” relationship, both partners may benefit from shared tangible resources, for example, partner income may contribute to maternal resources to increase the likelihood of being able to afford enough food for the household (Johnson et al., 2010). This relationship between tangible resources and household food insecurity may also be moderated by the level of trust in the relationship (Johnson et al., 2010; Piperata et al., 2016). Furthermore, according to the NIR model, the intimate dyad may provide key mental resources, such as relationship satisfaction, that bolster overall mental health and the pregnant woman's sense of security within the relationship and her perceptions of household food security (Johnson et al., 2010). Overall, the NIR model posits that mental and tangible resources are utilized at multiple levels (individual, intimate dyadic, and family) simultaneously and each can have an impact on perceived household food insecurity.

The benefit of the NIR model within the context of perceived household food insecurity among pregnant women is that it puts forth a wide-ranging conceptual model to predict risk, in this case risk of malnutrition, which can have significant consequences for maternal and child health during pregnancy (Ivers and Cullen, 2011). No studies, to our knowledge, conceptually bring together the constructs of resources (mental and tangible) operating at multiple levels (individual, dyadic, and family) to elucidate predictors of perceived household food insecurity among pregnant women. Improved understanding of risk factors and how they affect perceived food insecurity at multiple levels may be instrumental in creating effective interventions, especially where family or community level factors need to be addressed.

The purpose of the present study is two-fold: 1) to examine the utility of the NIR conceptual model in the context of studying perceived household food insecurity in order to further develop this theory; and 2) to tease apart how mental and tangible resources at varying levels (individual, intimate dyadic, and family) simultaneously influence perceived household food insecurity among pregnant women in South Africa, a key population that has not been adequately addressed in the current research. Thus, the hypotheses for the current study are as follows:

1. At the individual level, tangible and mental resources will predict maternal perceptions of household food insecurity.

2. At the family level, tangible resources will predict maternal perceptions of household food insecurity.
3. For women in relationships, tangible and mental resources at the intimate dyadic level will predict maternal perceptions of perceived household food insecurity.

1. Method

Participants were enrolled during pregnancy into the Drakenstein Child Health Study (DCHS), a population-based birth cohort study located in Paarl, South Africa, a small city located 60 km northeast of Cape Town (Zar et al., 2015; Stein et al., 2015). The Paarl public health system consists of well-established primary health clinics and one hospital where all births and hospital-based care occur. Pregnant women were recruited from two community-based clinic sites, Mbekweni (serving a predominately black African community) and TC Newman (serving a predominately mixed ancestry community). Our intention in using the historic terms of *black African* and *mixed ancestry* is not meant to reify these terms, but to contribute to the literature on ongoing health disparities. Both communities have substantial populations living in poverty and are comprised of a variety of dwellings, including government housing and informal housing. Table 1 reports data on key demographic variables for the two communities. The Faculty of Health Sciences Research Ethics Committee, University of Cape Town and the Provincial Research Committee provided ethical approval.

1.1. Enrollment and sample size

Women were eligible to participate if they attended one of the two study clinics, planned to stay in the study area for at least one year, and were at least 18 years of age. All mothers provided written informed consent at 20–28 weeks' gestation, prior to participation. Trained study staff obtained consent in mother's language of preference (English, isiXhosa or Afrikaans). In total, 1225 mothers enrolled between March 2012 and March 2015. Of these, 266 women stopped study participation prior to the antenatal study visit or did not complete the antenatal study visit. Due to the measure of perceived household food insecurity, only women with children living in the household were included; thus, 826 (median age 25) women were included in analyses.

1.2. Survey instruments

Measures were completed during the antenatal visit at 28–32 weeks' gestation using validated questionnaires administered by trained study staff. Participants completed measures to assess tangible and mental resources that may be related to perceived household food insecurity.

Individual-level tangible resources. Individual-level tangible resources were conceptualized as individual income, social assistance, and HIV status (physical health). To assess individual income, participants were asked "What is your own average income per month?" and responses were "Less than R1000 per month," "R1000-R5000 per month," "R5000-R10 000 per month," and "More than R10 000 per month." Due to the positive skew in this variable, it was recoded as "Less than R1000 a month" and "R1000 or greater per month" for regression analyses. Participants were also asked if they received social assistance. In South Africa, residents may receive a variety of state funded financial assistance including for childcare and/or disability. Participants were asked: "Do you receive any social assistance in the form of a government grant?" Responses were Yes/No.

According to the NIR model, physical health is a tangible

resource. In the South African context, HIV status is an important marker of physical health. HIV status for the study was established based on 1) rapid test results during pregnancy, 2) maternal hospital folder reviews, or 3) CD4 or viral load count results during pregnancy.

Individual-level mental resources. Individual-level mental resources were conceptualized as depression, experiences of childhood trauma, stressful life events, and psychological distress. These measures have previously been used in South Africa and both the Edinburgh Postnatal Depression Scale and the Self Reporting Questionnaire (SRQ-20) have been specifically validated in the South Africa context (Lawrie et al., 1998; van der Westhuizen et al., 2016).

Depression. The Edinburgh Postnatal Depression Scale (EPDS) was used to measure recent depressive symptoms (Cox et al., 1987). This scale has been validated for use with pregnant women (Murray and Cox, 1990). This scale consists of ten items referring to the past seven days and has response options ranging from 0 = *No, never* to 3 = *Yes, most of the time*. A total score was obtained by summing all items ($\alpha = 0.80$), with higher scores indicating more severe depressive symptoms.

Childhood trauma. Participants self-reported on their own experiences of childhood trauma including childhood abuse (physical, emotional, and sexual) and childhood neglect (physical, and emotional) using the Childhood Trauma Questionnaire – Short Form (CTQ-SF; Bernstein et al., 1994; Bernstein and Fink, 1998). Responses to the 28 items were recorded on a 5–point scale ranging from 1 = *never true* to 5 = *very often true*. Summed scores were used with a total possible range from 28 to 140. This scale had a substantial positive skew and was transformed using the logarithmic (log 10) method prior to use in regression analyses.

Stressful life events. The World Mental Health Life Events Questionnaire was used to assess participants' exposure to 13 areas of stressful/negative life events through 17 items during the past 12 months (Myer et al., 2008). Items were scored according to whether the event was experienced, 0 = *no*, 1 = *yes*. Individual items were then summed to create a total score, ranging from 0 to 17, with higher scores indicating greater exposure to stressful life events. This scale had a substantial positive skew and was transformed using the logarithmic (log 10) method prior to use in regression analyses.

Psychological distress. The Self Reporting Questionnaire (SRQ-20), a WHO-endorsed self-report measure, was used to assess psychological distress (Beusenberg and Orley, 1994). Items are scored according to whether the symptom is present, 0 = *no*, 1 = *yes*. Individual items were then summed to create a total score, ranging from 0 to 20, with higher scores indicating higher levels of psychological distress.

Family-level tangible resources. Tangible resources at the family-level were assessed through the item "What is your average household income per month?" Responses were "Less than R1000 per month," "R1000-R5000 per month," "R5000-R10 000 per month," "R10 000-R15 000 per month," and "More than R15 000 per month." Like individual-level income, for regression analyses this was recoded as "Less than R1000 a month" and "R1000 or greater per month."

Intimate dyadic tangible and mental resources. Participants also reported whether they were married or in a marriage-like relationship. If they reported being in a relationship, to assess tangible resources participants were asked about their partner's income, "What is your spouse/partner's average income per month?" Responses were "Less than R1000 per month," "R1000-R5000 per month," "R5000-R10 000 per month," and "More than R10 000 per month." Due to the positive skew in this variable, for regression analyses it was recoded as "Less than R1000 a month"

Table 1
 Characteristics of pregnant mothers enrolled in the birth cohort study (N = 826).

	TC Newman (N = 404)		Mbekweni (N = 422)		χ^2	p-value
	N	%	N	%		
Race						
Black	7	1.73	417	98.82	781.60	<0.001
Mixed Ancestry	397	98.26	4	0.95		
Household Income						
Less than R1000 per month	111	27.48	184	43.60	32.67	<0.001
R1000-R5000 per month	207	51.24	196	46.44		
R5000-R10 000 per month	56	13.86	39	9.24		
R10 000- R15 000 per month	9	2.23	1	0.24		
More than R15 000 per month	6	1.49	0	0.00		
Maternal Income						
Less than R1000 per month	304	75.25	341	80.81	5.66	0.13
R1000-R5000 per month	83	20.54	75	17.77		
R5000-R10 000 per month	7	1.73	2	0.47		
More than R10 000 per month	1	0.25	0	0.00		
Social Assistance (Government Grant)						
No	185	45.79	179	42.42	1.02	0.31
Yes	218	53.96	243	57.58		
Employment						
Not employed	284	70.30	339	80.33	11.35	<0.001
Currently employed	118	29.46	81	19.19		
Education						
Did not finish secondary education	245	60.64	270	63.98	0.89	0.35
Finished Secondary education or higher	158	39.11	152	36.02		
HIV status						
Negative	393	97.28	273	64.69	140.32	<0.001
Positive	11	2.72	149	35.31		
Food Insecurity						
Secure	353	87.38	218	51.66	123.38	<0.001
Insecure	51	12.62	204	48.34		
In a relationship						
No	228	56.44	278	65.88	8.01	<0.01
Yes	176	43.56	143	33.89		
Partner Income						
Less than R1000 per month	55	31.25	27	19.01	12.11	<0.01
R1000-R5000 per month	104	59.09	103	72.54		
R5000-R10 000 per month	11	6.25	12	8.45		
More than R10 000 per month	6	3.41	0	0.00		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i> -test	<i>p</i> -value
Number of people in household	5.84	2.61	5.21	2.48	3.52	<0.001
Quality of Relationship with Partner	8.12	1.68	8.17	1.94	-0.24	0.81
Depression	8.91	6.13	10.11	4.30	-3.18	<0.01
Childhood Trauma	38.32	12.91	34.4	9.74	4.82	<0.001
Stressful Life Events	2.66	2.42	1.44	1.98	7.71	<0.001
Psychological Distress	5.23	4.02	3.86	3.63	5.01	<0.001

NOTE: Some percentages do not add up to 100% due to missing data.

and “R1000 or greater per month.” To assess intimate dyadic mental resources, participants were asked to rate their relationship from 1 (indicating the worst possible marriage/relationship) to 10 (indicating the best).

Control variables. Household size, education, and employment are associated with the ability to obtain resources and the outcome variable of perceived household food insecurity and were measured and used as control variables (Bain et al., 2013; Bashir and Schilizzi, 2013). Participants were asked how many people normally live in their household. Participants were also asked about their education level: “How far did you get in school?” with responses “No education,” “Completed Grade 1 to Grade 5,” “Completed Grade 6 to Grade 7,” “Completed Grade 8 to Grade 11, i.e. High school without matriculating,” “Completed Grade 12, i.e. High school with matriculating,” “Part of university/college/post-matric education,” or “Completed university/college/post-matric education.” Responses were dichotomized to did not finish secondary education (i.e. high school) or finished secondary education or higher. Participants were asked about their current employment situation (“What is your current employment situation?”) and

given the option of selecting one of the following options: working now, self-employed, looking for work: unemployed, temporarily laid off, homemaker, student, illness/sickness, disabled, other. The options “working now” and “self-employed” were categorized as employment while all other options were coded as unemployed.

Perceived household food insecurity. Perceived household food insecurity was assessed using an adapted version of the short form of the USDA Household Food Security Scale (Bickel et al., 2000; Blumberg et al., 1999). Due to our setting of widespread poverty, the questions referred to children in the home to gain a more conservative estimate of perceived household food insecurity. Studies conducted in Africa show support for parental buffering of food insecurity such that children are often the last members of the household to experience food insecurity (Hadley et al., 2008; Kuku et al., 2011). The items were as follows: “In the last 3 months, were any meals made smaller for the children in your home because there wasn't enough money for food?” (Responses were Yes/No) “In the last 3 months, did any children in the household ever skip the following meals because there wasn't enough money for food?” (Responses were Breakfast, Lunch, Supper, No meals skipped), “If

yes, how often did this happen in the past three months?" (Every month, During one month, During two months), "In the last 3 months, were any children in the household ever hungry but you just couldn't afford more food?" (Responses were Yes/No), and "In the last 3 months, did any children in the household ever not eat for a whole day because there wasn't enough money for food?" (Responses were Yes/No).

Using the guidelines from the USDA Household Food Security Scale – Short Form (Bickel et al., 2000), an affirmative response to two or more items was coded as perceived household food insecurity (HFI). Because of the wording of these items, only women who reported having children in the household were included in these analyses (826/959; 86%).

1.3. Statistical analyses

Means and rates were calculated to characterize the sample. To test differences between the communities on demographics, psychosocial, and behavioral variables chi-squares and independent samples t-tests were used. All variables were examined for skew and kurtosis and if found to be not normally distributed were transformed prior to use in the regression analyses.

Hierarchical logistic regressions were built, each adding a new block of variables to test how well tangible and mental resources predicted perceived household food insecurity at the individual and family levels. Although the variables of interest involve constructs at multiple levels, all data were collected at the individual level, with women reporting on characteristics of their partners and households. Thus, hierarchical logistic regressions were chosen as the appropriate statistical tests, rather than multilevel modeling. Given the important differences between the two communities in demographics, separate hierarchical regressions were conducted for each community. Because only a portion of participants reported being in a relationship (38%), sub-analyses were conducted to examine the associations between intimate dyadic tangible and mental resources for these women. For all hierarchical logistic regressions, Adjusted Odds Ratios (AOR) and p-values are reported. Likelihood Ratio chi-square tests are reported for each regression block to test for the significance of the contribution of the additional predictors in the block to the model (Cohen et al., 2003). We also tested for multicollinearity and found no issues in these analyses. IBM SPSS 22 was used for descriptive and hierarchical logistic regression analyses.

Some participants had partially missing data (65/826, 7.8%). Missing data were assumed to be Missing At Random (MAR; Harel et al., 2012) and were handled via a missing data sensitivity analysis. Using multiple imputation by chained equations, missing data were estimated using all variables in the dataset and predictive mean matching using the R package "mice: Multivariate Imputation by Chained Equations" version 2.25 (van Buuren and Groothuis-Oudshoorn, 2011, 2016).

2. Results

Demographics differed greatly between the two communities (Table 1). Maternal and household income was low in both communities (majority of women had monthly incomes of less than R1,000, approximately 100USD/month), although women at TC Newman had higher monthly household incomes compared to Mbekweni participants. Women in TC Newman were also more likely to be employed. Most HIV positive women were from the Mbekweni community. Women in Mbekweni were also more likely to perceive household food insecurity (HFI) and were less likely to be in a relationship. Women in Mbekweni had higher depression but women in TC Newman had higher rates of childhood trauma,

more stressful life events, and higher levels of psychological distress.

2.1. Hierarchical logistic regressions testing NIR predictors of household food insecurity

Among women in both communities ($N = 761$), HIV status (a marker of physical health) significantly predicted perceived household food insecurity (HFI, Table 2, Block 3; Adjusted Odds Ratio (AOR) = 1.74, $p = 0.01$). No other individual-level tangible resources predicted HFI, however, several individual-level mental resources did. Both depression and childhood trauma significantly predicted HFI, such that higher levels of depression (AOR = 1.06, $p < 0.01$) and higher levels of childhood trauma (AOR = 6.35, $p = 0.03$) were associated with increased odds of perceiving household food insecurity. Family-level tangible resources, however, did not significantly predict HFI. Finally, community was significantly associated with HFI (AOR = 6.15, $p < 0.001$). To explore the differences between communities, these analyses were replicated for each community.

In the final TC Newman model (Table 3, Block 3), for individual-level tangible resources, maternal income was a significant predictor, such that women with higher personal incomes had a lower likelihood of experiencing HFI (AOR = 0.16, $p = 0.01$). Additionally, receiving social assistance was associated with higher odds of experiencing HFI (AOR = 2.37, $p = 0.04$). HIV status was not a significant predictor of HFI, likely due to the small number of HIV positive women in this community ($N = 16$). None of the individual mental resources significantly predicted HFI in this community, although childhood trauma was trending as a predictor (AOR = 13.77, $p = 0.07$).

In the final Mbekweni model (Table 4, Block 3), for individual-level tangible resources, HIV status was the only significant predictor, with women living with HIV almost twice as likely to perceive household food insecurity (AOR = 1.93, $p < 0.01$). For individual-level mental resources, depression was the only significant predictor of HFI, such that higher levels of depression were associated with a greater likelihood of HFI (AOR = 1.08, $p < 0.01$). Household income, a measure of family tangible resources, was not significant.

2.2. Intimate dyadic sub-analyses

To test the influence of interpersonal factors, in particular, the influence of intimate dyadic tangible and mental resources, sub-analyses were conducted with pregnant women that reported being in a marriage or marriage-like relationship (self-defined as a steady partner). Among women in both communities, partner income was trending as a predictor of HFI when first entered the model (Table 5, Block 3, AOR = 0.52, $p = 0.08$) but did not predict HFI once household income was controlled (Table 5, Block 4, AOR = 0.59, $p = 0.20$). The measure of intimate dyadic mental resources, relationship quality, was not significantly associated with HFI. These analyses were replicated by community and similar trends of intimate dyadic tangible and mental resources not being significant predictors of HFI were found (Data not shown but available upon request).

2.3. Missing data sensitivity analyses

Data were partially missing in both communities (Mbekweni $N = 28$, TC Newman $N = 37$), that was handled using listwise deletion in the above analyses. We conducted missing data sensitivity analyses using multiple imputation chained equations (MICE) to examine whether these missing data impacted our results. All

analyses replicated and those findings reported as significant remained significant when imputing the missing data (Data not shown but available upon request). The fraction of information about the regression coefficients missing due to nonresponse was low (across all analyses ranging from 0.004 to 0.16) contributing to our confidence in the estimates presented above.

3. Discussion

This study, to our knowledge, is the first to use the Network-Individual-Resource Model (Johnson et al., 2010) to examine multilevel predictors of perceived household food insecurity among pregnant women. We investigated tangible and mental resources at the individual, intimate dyadic, and family levels. These analyses support our hypothesis that both tangible and mental resources at the individual level predict perceived household food insecurity. Importantly, the specific resources that predict perceived household food insecurity are dependent on context/community. In TC Newman, the mixed ancestry community where women had slightly higher incomes compared to the other community, making less than R1000 per month and receiving social assistance were associated with perceived household food insecurity, while being HIV positive was not. However, in Mbekweni, the black African community with higher prevalence rates of HIV, being HIV positive was associated with perceived household food insecurity, whereas, income and social assistance were not. Although we did not directly test the impact of community level tangible and mental resources, these differential findings based on community allude to the impact these resources may have on perceived household food insecurity and represent an avenue of further investigation.

Additionally, depression and childhood trauma were significant predictors of perceived household food insecurity in the analysis of both communities. Psychosocial factors may inhibit a woman's ability to obtain food or to sustain regular employment (Garg et al., 2015; Leung et al., 2015). Conversely, food insecurity may give rise to depression or mental distress impeding a woman's ability to obtain safe and nutritious food (Dewing et al., 2013; Piperata et al., 2016), creating a bidirectional relationship (Huddleston-Casas et al., 2009). This highlights the importance of addressing psychosocial factors during the critical time of pregnancy, not only for the mother's well-being, but for infant outcomes associated with

household food insecurity (Natamba et al., 2016).

Our results did not support our hypothesis that intimate dyadic resources (tangible or mental) would predict perceived household food insecurity, which is particularly interesting in the context of pregnancy, when women may rely more on their partners monetarily and emotionally (Pafs et al., 2016). According to the NIR model and some emerging evidence from the food insecurity literature, there may be limits to the impact that partner support has on household food insecurity for a variety of reasons, including when the type of support does not match the actual need or when trust is reduced within the partnership (Johnson et al., 2010; Piperata et al., 2016). Further, our sample does have high levels of intimate partner violence (data not shown) and low levels of women who are married or cohabiting with the father of their child; thus, there may be very low levels of partner support even when the sample reported having a partner. Additionally, it is possible that there are other specific tangible and mental resources within the intimate dyadic relationship that we did not measure that predict perceived household food insecurity, such as trust in the relationship and communication skills. Although we did have a measure of partner income, we did not collect information on how much the partners shared this income with the pregnant women. Recent research shows that when women have control over the household spending, household food insecurity is significantly lower (Schmeer et al., 2015). More information regarding resource sharing within this small dyadic network would be helpful to further investigate this possibility.

Family tangible resources did not significantly predict perceived household food insecurity. Although, household income did not predict perceived household food insecurity, number of people in household (a control variable) was a significant predictor in the TC Newman community, such that more people in the household was associated with a higher likelihood of perceived household food insecurity. The number of people in the household is likely related to resource sharing within the family, however, we do not have specific information regarding how resources were shared within the family, and, thus, considered it a control variable rather than a tangible resource variable. We also did not collect information on mental resources at the family level, such as social support and trust, which could have a significant impact on household food insecurity during pregnancy. These combined findings on family tangible resources with number of people indicate that future

Table 2
Hierarchical logistic regression predicting food insecurity with pregnant women from both communities (N = 761).

Variables	Block 1		Block 2		Block 3	
	Adjusted OR	p-value	Adjusted OR	p-value	Adjusted OR	p-value
Individual Tangible Resources						
Individual Income (R1000 or greater)	0.59	0.06	0.60	0.07	0.66	0.14
Receiving Social Assistance	1.23	0.28	1.33	0.15	1.36	0.12
HIV Positive Status	1.81	<0.01	1.72	0.02	1.74	0.01
Individual Mental Resources						
Depression (EPDS)			1.07	<0.01	1.06	<0.01
Childhood Trauma			6.51	0.03	6.35	0.03
Stressful Life Events			0.69	0.29	0.69	0.29
Psychological Distress			1.03	0.26	1.03	0.25
Family Tangible Resources						
Household Income (R1000 or greater)					0.80	0.27
Control Variables						
Community	5.56	<0.001	6.32	<0.001	6.15	<0.001
Number of People in Household	1.03	0.33	1.03	0.44	1.03	0.42
Individual Part or Full Time Employment	0.74	0.24	0.76	0.30	0.79	0.37
Individual Finished Secondary Education	0.48	<0.001	0.52	0.001	0.53	<0.01
	Block $\chi^2(df)$	p-value	Block $\chi^2(df)$	p-value	Block $\chi^2(df)$	p-value
	13.49 (3)	<0.01	27.39 (4)	<0.001	1.22 (1)	0.27

Table 3
Hierarchical logistic regression predicting food insecurity with pregnant women from TC Newman ($N = 367$).

Variables	Block 1		Block 2		Block 3	
	Adjusted OR	<i>p</i> -value	Adjusted OR	<i>p</i> -value	Adjusted OR	<i>p</i> -value
Individual Tangible Resources						
Individual Income (R1000 or greater)	0.23	0.03	0.17	0.01	0.16	0.01
Receiving Social assistance	2.12	0.06	2.37	0.04	2.37	0.04
HIV Positive Status	1.24	0.82	0.98	0.99	0.99	0.99
Individual Mental Resources						
Depression (EPDS)			1.05	0.19	1.05	0.20
Childhood Trauma			13.81	0.07	13.77	0.07
Stressful Life Events			1.39	0.60	1.39	0.60
Psychological Distress			1.05	0.38	1.05	0.38
Family Tangible Resources						
Household Income (R1000 or greater)					1.02	0.95
Control Variables						
Number of people in household	1.12	0.04	1.14	0.03	1.14	0.03
Individual Part or Full Time Employment	0.96	0.93	1.11	0.83	1.11	0.83
Individual Finished Secondary Education	0.13	<0.01	0.14	<0.01	0.15	<0.01
	Block $\chi^2(df)$	<i>p</i> -value	Block $\chi^2(df)$	<i>p</i> -value	Block $\chi^2(df)$	<i>p</i> -value
	10.09 (3)	0.02	18.31 (4)	<0.01	0.004 (1)	0.95

Table 4
Hierarchical logistic regression predicting food insecurity with pregnant women from Mbekweni ($N = 394$).

Variables	Block 1		Block 2		Block 3	
	Adjusted OR	<i>p</i> -value	Adjusted OR	<i>p</i> -value	Adjusted OR	<i>p</i> -value
Individual Tangible Resources						
Individual Income (R1000 or greater)	0.78	0.41	0.85	0.60	0.94	0.85
Receiving Social Assistance	1.02	0.94	1.07	0.78	1.12	0.65
HIV Positive Status	1.93	<0.01	<0.01	<0.01	1.93	<0.01
Individual Mental Resources						
Depression (EPDS)			1.08	<0.01	1.08	<0.01
Childhood Trauma			4.13	0.19	3.89	0.21
Stressful Life Events			0.54	0.15	0.54	0.15
Psychological Distress			1.03	0.42	1.03	0.37
Family Tangible Resources						
Household Income (R1000 or greater)					0.76	0.26
Control Variables						
Number of People in Household	0.99	0.82	0.98	0.68	0.98	0.66
Individual Part or Full Time Employment	0.67	0.20	0.69	0.23	0.73	0.32
Individual Finished Secondary Education	0.64	0.05	0.68	0.10	0.69	0.11
	Block $\chi^2(df)$	<i>p</i> -value	Block $\chi^2(df)$	<i>p</i> -value	Block $\chi^2(df)$	<i>p</i> -value
	9.92 (3)	0.02	13.05 (4)	0.01	1.27 (1)	0.26

Table 5
Hierarchical logistic regression predicting food insecurity with pregnant women from both communities who report having partners ($N = 291$).

Variables	Block 1		Block 2		Block 3		Block 4	
	Adjusted OR	<i>p</i> -value	Adjusted OR	<i>p</i> -value	Adjusted OR	<i>p</i> -value	Adjusted OR	<i>p</i> -value
Individual Tangible Resources								
Individual Income (R1000 or greater)	0.87	0.71	0.82	0.61	0.94	0.89	0.98	0.95
Receiving Social Assistance	1.57	0.27	1.93	0.13	1.87	0.16	1.88	0.15
HIV Positive Status	1.73	0.12	1.42	0.35	1.52	0.27	1.56	0.24
Individual Mental Resources								
Depression (EPDS)			1.05	0.13	1.05	0.16	1.05	0.16
Childhood Trauma			6.83	0.19	8.83	0.15	8.84	0.15
Stressful Life Events			1.12	0.84	1.12	0.85	1.12	0.85
Psychological Distress			1.12	0.02	1.106	0.04	1.11	0.03
Intimate Dyadic Tangible Resources								
Partner Income (R1000 or greater)					0.52	0.08	0.59	0.20
Intimate Dyadic Mental Resources								
Relationship Quality					1.00	0.85	1.00	0.86
Family Tangible Resources								
Household Income (R1000 or greater)							0.77	0.54
Control Variables								
Community	4.72	<0.001	8.26	<0.001	9.05	<0.001	9.16	<0.001
Number of People in Household	1.08	0.25	1.08	0.27	1.07	0.35	1.08	0.32
Individual Part or Full Time Employment	0.62	0.22	0.67	0.34	0.65	0.30	0.67	0.35
Individual Finished Secondary Education	0.29	<0.01	0.32	<0.01	0.34	<0.01	0.34	<0.01
	Block $\chi^2(df)$	<i>p</i> -value	Block $\chi^2(df)$	<i>p</i> -value	Block $\chi^2(df)$	<i>p</i> -value	Block $\chi^2(df)$	<i>p</i> -value
	4.32(3)	0.23	22.80 (4)	<0.001	3.35 (2)	0.19	14.41 (4)	<0.01

investigations should incorporate a detailed measure of intra-household allocation if possible to better understand resource partitioning among family members.

4. Limitations

There are several other limitations to this study. These analyses utilize cross-sectional data during pregnancy, and thus, claims of causation cannot be made. Another limitation of these analyses was our measure of perceived household food insecurity. The adapted short form of the USDA Household Food Security Scale (Blumberg et al., 1999; Bickel et al., 2000) was used and thus was not validated in its present form. Additionally, the questions referred to children in the household, who are often the last ones to go hungry in a household. This may have made our estimates of food insecurity too conservative. Furthermore, the questions do not specifically speak to maternal food insecurity, which possibly have different significant predictors. For example, self-income may have been significant across both studies due to the relationship between monetary funds and maternal food insecurity (Schmeer et al., 2015). Additionally, we may have found the mental health resources to be more consistently significant across the communities based on previous research in high-income countries (Laraia et al., 2006; Whitaker et al., 2006). However, given the role of families and household units in the South African context, we feel that the significant predictors in the current study add value to the literature. Future research on food insecurity during pregnancy in South Africa should utilize a combination of individual- and household-level food insecurity indicators.

Additionally, although we examined several factors that operate at multiple levels (individual, intimate dyadic, family), the data were only collected at the individual level. A stronger study design would be to collect these data at multiple levels and to analyze the data using multilevel modeling, which should be considered as an important direction for future research. Another limitation of these analyses is the possibility of interplay between the psychosocial variables such that one psychosocial variable may mediate the relationship between another psychosocial variable and household food insecurity. Additionally, several of the psychosocial variables may be exacerbated or caused by experiences of food insecurity (Huddlestone-Casas et al., 2009). Our analyses could not account for this possible cyclical relationship. Finally, it should be noted that these findings may not be generalizable to other areas of South Africa or outside the South African context. However, many of the factors identified, such as poverty, mental health issues, HIV, and education for women, are widespread in African and LMIC settings (Bain et al., 2013; English et al., 2015; Fisher et al., 2012; Hegdahl et al., 2016).

5. Conclusions

This study provides us with more information regarding perceived household food insecurity during pregnancy in South Africa, an identified gap within the literature. We found that economic and health factors (tangible resources) along with psychosocial factors (mental resources) predict perceived household food insecurity among pregnant women in South Africa, mirroring findings in general populations. Furthermore, this study is the first, to our knowledge, to investigate the utility of the Network-Individual-Resource Model in examining predictors of perceived household food insecurity. This study shows promise for the use of the NIR model, particularly regarding individual-level mental and tangible resources, as well as the impact of community. This study develops our conceptual understanding of household food insecurity for a high priority population – pregnant women in a setting

with high HIV prevalence – using a conceptual model for HIV now being applied to understand food insecurity among women in an HIV affected environment. Additional research should evaluate additional mental and tangible resources at all levels specified by the model (individual, intimate dyadic, family, peers/community, and society) longitudinally to provide a more comprehensive picture of the factors that influence food insecurity during pregnancy for women living in South Africa and other LMICs.

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Conflict of interest

None of the authors have any conflicts of interest to declare.

Ethical standards disclosure

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Faculty of Health Sciences Research Ethics Committee, University of Cape Town and the Provincial Research Committee. Written informed consent was obtained by all subjects.

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