

Impact of women's empowerment on household vulnerability to food insecurity within the rural economy of Pakistan

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Empowering women living in the rural economies of the developing world is important to reduce the vulnerability of agricultural households to food insecurity. Despite the existing literature on food insecurity, only a few studies have investigated household vulnerability to food insecurity - important for devising policies and strategies to eradicate food insecurity. This study aims to evaluate the impact of rural women's empowerment in reducing household's vulnerability to food insecurity using a household vulnerability to food insecurity index (HVFII) and a rural women composite empowerment index (RWCEI) which has multiple domains. Data from the Pakistan rural household panel survey data of 1868 farming households was analysed using a multi-level mixed effects ordered logistic approach. Descriptive statistics indicate that 33% and 14% of households face severe to mild vulnerability to food insecurity respectively. Of all the domains, rural women are particularly disempowered in economic autonomy and education. Multi-level modelling demonstrated that women's empowerment overall has positive and significant impact in mitigating the risks related to household food insecurity. Other factors included age of the head of household, and accessing a safety net program, and community infrastructure. The study suggests that those responsible for mitigating household vulnerability to food insecurity in rural Pakistan should specifically focus on empowering women, particularly helping them to be economically autonomous, and providing more information on health and food.

Keywords: Women Empowerment Index; food insecurity risks; multi-level; mixed effects; ordered logistic model; rural economy; Pakistan

INTRODUCTION

Background: Food insecurity needs to be eradicated globally. It is defined as "limited or uncertain availability or ability to acquire nutritionally adequate and safe foods in socially acceptable ways" (Bickel *et al.*, 2000). Despite the substantial efforts made by the governments and international organizations to reduce the prevalence of food and nutrition insecurity in the world, millions of people are still vulnerable (Moreda, 2018). Globally, two billion people (25.94% of the world's population) are food insecure (FAO, 2020), with the highest percentage in developing nations (Drysdale *et al.*, 2019; Eshetu and Guye, 2021; FAO, 2021). Asia is the region reflecting the highest percentage of world food insecurity, with over one billion people affected (77.44%) (FAO, 2020). Among the food insecure and undernourished countries of Asia, Pakistan is one of the most susceptible ones. According to Global Food Security Index (GFSI) and Global Hunger Index (GHI), Pakistan is ranked at 78 out of 113, and 88 out

of 107 countries, respectively (GFSI, 2019; GHI, 2020) demonstrating severe food insecurity. Keeping the statistics in mind, multiple experts have attempted to address the topic in various policy discussions and concentrated on finding solutions to the problem.

Previous studies have estimated food insecurity by considering current food consumption (determined by the caloric intake) (Azeem *et al.*, 2016; Ibok *et al.*, 2019; Mthethwa and Wale, 2021). However, it has become obvious in recent years, that food insecurity analysis must be conducted in a dynamic environment (Eshetu and Guye, 2021). Measuring the present impact of food insecurity is insufficient without understanding the characteristics of people, households, or communities who are vulnerable to food insecurity in the future. Food vulnerability means, "the ability of a household to cope with food-related shocks in a stressful situation in order to meet their food needs". The vulnerability to food insecurity approach estimates both household's probability of losing access to safe and adequate



food in the coming future (Babatunde *et al.*, 2008), and failure to attain certain wellbeing levels (Bhalla *et al.*, 2018).

The vulnerability approach has two main advantages. Firstly, it is a forward-looking concept (Mthethwa and Wale, 2021) because it focuses not only on the current outcomes of food insecurity but also on future incidences. Secondly, it considers the risks and uncertainties that are linked with food insecurity in the future (Scaramozzino, 2006). Household-level risks include health risks (e.g. disability, illness, injuries, accident); life process-related risks (e.g. death, dowry, old age); economic risks (e.g. unemployment, price shocks); and natural disasters (e.g. flood, earthquake, drought) (Babatunde *et al.*, 2008). These risks augment food and nutrition insecurities in the coming future by triggering different pitfalls like cutbacks on food consumption, assets, and savings and the appearance of different types of nutritional diseases and disorders (Lovendal *et al.*, 2006).

Research has investigated the role of many socio-economic factors including education, family size, employment, income, assets, wealth, dependency ratio, land size, food shortage to combat the problem (Farzana *et al.*, 2017; Eshetu and Guye, 2021). However, few studies have focused on exploring the women's role as the root cause of the problem (S. Dauda, 2010; Sharaunga *et al.*, 2015). This is despite women being regarded as an essential element of the home in terms of sustaining and supplying food for their families (Sraboni and Quisumbing, 2018). Furthermore, in countries like Pakistan, where subsistence farming is the main source of income, rural women perform a variety of tasks in food production, processing, and preparation (Naz *et al.*, 2014; Aziz *et al.*, 2020). Hence, women's contributions need to be explored in terms of impacts, especially in the arenas of mitigating food insecurity and household vulnerability.

Rural women's empowerment and household vulnerability to food insecurity (HVFI): women's empowerment is argued to be an important development goal for two main reasons. First, it is a basic human right. Second, it is considered not only an important sustainable development goal (SDG) in itself, but also crucial in achieving other SDGs, such as household food and nutrition security (Agarwal, 2018). Several studies have empirically investigated the impact of women's empowerment on household vulnerability to food insecurity (Ali and Vallianatos, 2017). In general, research in this area demonstrates that women's empowerment has a favourable impact on reducing food insecurity risks. Harris-fry *et al.* (2015) argued that woman could play a significant role in mitigating the effect of risk factors on household food insecurity in three rural Bangladeshi regions. They found that women's land ownership, relative wealth, literacy, media access, and market access all considerably reduce the risks of food insecurity.

The relationship between women's empowerment and food security is particularly important in rural areas. According to Baiphethi and Jacobs (2009), one of the benefits of

empowering rural women is that more food can be produced for local consumption and as well as for sale in local markets. Moreover, they considered that rural women's empowerment is the best pathway in reducing household vulnerability to food insecurity by ensuring food availability and increasing agricultural incomes. This argument is founded on the fact that in rural regions, women play an important role as food producers, wage earners, and custodians of food and nutrition security (Galié, 2013). Mayoux (2005) stated that investments in women's empowerment led to improved health and education, reduced poverty and food insecurity vulnerability, and economic growth.

Since the foundation of Pakistan women's contributions have been overlooked in many aspects of life, notably in agriculture (Drucza and Peveri, 2018). Authors argue that if women are provided with equal opportunities and privileges like men of their society, then food security and resilience in rural communities could be enhanced. Similarly, in the agricultural sector, women's empowerment leads to more sustainable means of feeding homes by generating cash from the sale of surplus product, lowering household vulnerability to food insecurity.

Based on the literature, the impact of women's empowerment may include ensuring food security; maintaining the nutritional status of families; reducing household vulnerability to food insecurity; and more sustainable livelihoods. Furthermore, women's empowerment is seen as a critical component in providing the most disadvantaged households with the resources they need to secure their livelihoods and food security (Sharaunga *et al.*, 2015), thereby potentially reducing health inequalities.

This research in Pakistan is needed because of second main gaps in the household vulnerability to food insecurity literature. First, despite substantial evidence on conceptual and theoretical frameworks of food vulnerability, empirical research about its application is limited in Pakistan (Ahmad and Farooq, 2010). Previous studies examined the role of various determinants in vulnerability analysis, did not include the role of women in mitigating the risks towards food insecurity (Sharaunga *et al.*, 2016). Second, studies that have researched women's empowerment used proxy variables and did not include some wider domains considered to be important. We have developed an index which includes nine domains of women empowerment and is much broader than previous definitions. Third, there is dearth of knowledge in literature which evaluates household vulnerability to food insecurity in the context of contextual variations. Our research assumes that households are nested inside the communities, and that communities play a key role in influencing family food security. In previous studies community level differences have not been incorporated in the empirical analysis and present study is attempting to fill this gap. The current study's aim is to empirically examine the influence of rural women's empowerment on household vulnerability to

food insecurity in Pakistan's rural areas. We hypothesized that rural women's empowerment significantly contributes to reduce the risks related to food insecurity.

MATERIALS AND METHODS

Data and Study Area: The present study employed the data taken from the Pakistan Rural Household Panel Survey (PRHPS) (IFPRI/IDS 2012-2014)². The data was collected in three rounds carried out between March 2012 and June 2014 from rural areas of Pakistan comprising of 19 districts: 12 districts of Punjab; two districts of Khyber Pakhtunkhwa (KPK); and five districts of Sindh. The Baluchistan province was excluded from the sample due to security concerns. Four Mouzas³ (villages) were randomly selected from 76 in each of 19 districts. The PRHPS used a multistage stratified technique for sampling. Structured questionnaires were designed, and personal interviews were conducted for data collection. We used data from third round survey containing 1868 households and 19 districts (communities). We analysed data from survey module on females, males, households and communities. The complete data set is present in IFPRI dataverse archive and publicly accessible at: <https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/JWMCXY>

Variable construction

Dependent Variable: Construction of household vulnerability to food insecurity index (HVFII): The conceptual framework of Ibok *et al.* (2019) is employed for the present study in the estimation of HVFII in Pakistan. It can be examined at three levels i.e. exposure, sensitivity, and adaptive capacity (IPCC, 2001; IPCC, 2007; Antwi-agyei *et al.*, 2012; Ibok *et al.*, 2019). Exposure level express food-related shocks, that may endanger the household's food availability in near future. This level of shock reflects the extent to which a household faces risk, danger, or hazard (IPCC, 2001; Antwi-agyei *et al.*, 2012). Households respond to these shocks by making use of their valuable assets. Seen through a vulnerability lens, a household's ability to react is called its adaptive capacity which is defined as the ability of a household to efficiently adapt to the effects of food-related shocks through coping strategies (Engle, 2011). Households with a high adaptation capacity are more resilient in the face of shocks and are more likely to adjust to food insecurity. Sensitivity refers to the system's degree of responsiveness towards stress conditions (IPCC, 2001). It reflects the effects of food shocks such as hunger, malnutrition, or mortality on households. These were used in the formation of an index as they demonstrate accumulative effect of food insecurity on

households (Ibok *et al.*, 2019). Table 1 categorizes the HVFII domains, indicators, and related variables.

In the next step weights for these indicators and domains were assigned by using Principal Component Analysis (PCA) (Gbetibouo *et al.*, 2010). Finally, HVFII scores computed by using aggregation method as shown in the following equation:

$$HVFII_h = \sum AC_h - [\sum E_h + \sum S_h] \dots\dots\dots(1)$$

Where, E_h is the index of exposure domain, S_h is the index of sensitivity domain and AC_h is the index of adaptive capacity. Households with negative or lower HVFII composite scores were more exposed to food insecurity than those with positive or higher HVFII composite values. Higher the composite score, lower is the vulnerability towards household food insecurity. Finally, by using these composite scores the household's response towards a shock is classified into three categories: i) highly vulnerable; ii) mildly vulnerable; and iii) not vulnerable to food insecurity. Justification for using categorical variable instead of continuous is that we were interested in visualising the percentage of households in each of these categories. Moreover, we were also interested to examine results using the non-vulnerability status of households (i.e., third response category).

HVFII Threshold: A household may be sensitive to, or in danger of, food insecurity yet just stating that this household is vulnerable is insufficient. Thus, a household is considered vulnerable when its adaptive capacity is insufficient and remain unable to adjust it successfully in the stressful conditions of exposure and sensitivity. HVFII threshold defined for the present study is where household's adaptive capacity is greater than the combined impact of exposure and sensitivity. For the purposes of this study, the HVFII threshold is defined as the point at which a household's adaptive capacity exceeds the combined impact of exposure and sensitivity. For this estimation each domain is given equal weight of 0.33, i.e., each domain represents one third of the proportion of vulnerability (Ibok *et al.*, 2019).

When;

if: $(E_h + S_h) > AC_h$,
household will be vulnerable to food insecurity

if: $(E_h + S_h) < AC_h$,
household will not be vulnerable to food insecurity

Independent variables

Construction of Rural Women Composite Environment Index (RWCEI). The underlying framework for the construction of our Rural Women Composite Empowerment Index (RWCEI) was adopted from the 'Women Empowerment in Agriculture Index (WEAI)' (Alkire and Foster, 2011; Alkire *et al.*, 2013). The WEAI was developed to represent women's

² This survey period mostly overlapped with harvesting of Rabi (summer) crops and cultivation of Kharif (winter) crops. The cultivation and harvesting time in Pakistan differ slightly from province to province.

³ A mouza is an administrative unit based on land revenue records and may correspond to a specific land with one or more settlements.

empowerment status in the agricultural sector and bring empowerment to the foreground of the policy agenda. WEAI consists of five domains and ten indicators to represent women's empowerment in agriculture sector and has been used to draw comparisons among countries, contexts, and time. Since women empowerment is a multidimensional and context-specific concept, indicators might be relevant for some regions and irrelevant for other places and times. Hence, measuring women empowerment through standard indicators

does not apply to all places and times. In the case of Pakistan, the present study developed indicators relevant in the context of rural areas. The Rural Women Composite Empowerment Index (RWCEI) measures empowerment through nine domains (economic empowerment, autonomy, decision making, education and skill empowerment, time allocation, mobility, political empowerment, awareness, and violence); fourteen sub-domains; and eighty-nine indicators .

Table 1. Domains and indicators used for the construction of vulnerability to household food insecurity index (VHFII).

Domains	Indicators	Description of Variables
Exposure probability of covariate shocks occurring	Health Shock	<ul style="list-style-type: none"> • Illness / Accident / Disability of main earning member of the household • Medical expenses due to illness or injury • Death of main earning member of the household
	Unemployment Shock	<ul style="list-style-type: none"> • A member lost job • Expecting a job but couldn't find employment • Lowered income of any member • Bankruptcy • Loss of assets • Unusual increase in rent • Unusual increase in other prices • Dowry payment • Family dispute on property
	Natural Disaster	<ul style="list-style-type: none"> • Flood • Drought • Crop Insect/disease outbreak • Epidemic • Earthquake • Fire • Storm
	Food price shock Civil conflict shock	<ul style="list-style-type: none"> • Increase in price of major food items consumed • Loss of Harvest due to natural calamities • Theft of livestock • Kidnapping • Violence against women • Honour killing • Murder • Dowry/Cost of marriage
Sensitivity Previous/accumulative experience of food insecurity	Malnutrition	<ul style="list-style-type: none"> • Length/height-for-age (stunting)
	Child mortality Hunger	<ul style="list-style-type: none"> • Total number of children dead in each household • Total number of days' households gone without eating any food
Adaptive capacity how household respond, exploit opportunities, resist or recover from food insecurity shocks	Wealth Index	<ul style="list-style-type: none"> • Agricultural Assets • Mobility Assets • Livelihood Assets • Housing structure characteristics
	Access to infrastructure	<ul style="list-style-type: none"> • Household distance to nearest major road (km). • Household distance to nearest market (km). • Time taken to walk one way to the water source from household dwelling (minutes).
	Livelihood activities	<ul style="list-style-type: none"> • Total income of household from savings, property's rent and income of other types • Estimated revenue from non-farm businesses • Total yield of crops harvested (kg)
	Household literacy	<ul style="list-style-type: none"> • Cumulative years of schooling for household heads or closest individual⁴ in the household.

⁴ This is the next individual in the household if education will be missing for the household head, who has the highest level of education, and at least five years of schooling. If educational

qualifications are the same for more than one individual, the most senior individual in age will be used.

Table 2. List of variables used in the analysis.

Variables	Description	Measurement	Previous Studies
Household Predictors			
Sex of HH* head	Female headed households	(Female=1, Male = 0)	(Azeem <i>et al.</i> , 2016), (Eshetu and Guye, 2021)
Age of HH head	Age of head in years	Continuous variable	(Azeem <i>et al.</i> , 2016) (Eshetu and Guye, 2021)
Household Size	Number of household members in an family	Continuous variable	(S. Sharaunga <i>et al.</i> , 2016), (Azeem <i>et al.</i> , 2016), (Eshetu and Guye, 2021)
Number of children in HH	Number of all children residing in one household	Continuous variable	(Ekbrand and Halleröd, 2018)
Employment status of HH	Head of HH involve in primary or secondary occupation (Agriculture, non-agriculture, Private, business entrepreneurship)	(Yes =1, No =0)	(Savari <i>et al.</i> , 2020)
Agriculture employment	Household either involved in agricultural occupation or not	(Yes = 1, No = 0)	(Sraboni <i>et al.</i> , 2014), (Azeem <i>et al.</i> , 2016), (Farzana <i>et al.</i> , 2017)
Non-farm employment	Household either involved in non-farm occupation or not	(Yes = 1, No = 0)	(S. Sharaunga <i>et al.</i> , 2016) (Eshetu and Guye, 2021)
Dependency ratio	It is the ratio of dependents that are not in the labour force (ages 0 to 14 and 65+) and those typically in the labour force (ages 15 to 64)	Continuous variable	(Hahn <i>et al.</i> , 2009)
Total land (Acres)	Agricultural land owned by household	Continuous variable	(Eshetu and Guye, 2021)
HH Wealth Index	Information about livestock assets, house ownership and quality of house material, sanitary condition, quality of water and energy source	4 quantiles generated by using PCA	(Alkire <i>et al.</i> , 2013)
Participation in social safety net programs	Household receiving benefits from programs like, BISP, PRSP, NRSP, PPAF, Bait-ul-mal, Zakat, Edhi, Punjab Food Support Program, PM's Youth Employment Program etc.	(Yes =1, No = 0)	(Scaramozzino, 2006), (Eshetu and Guye, 2021)
HH Food Expenditures	Expenditures on daily food items	Continuous variable	(Scaramozzino, 2006)
Food and nutrition security predictors			
Food Consumption Scores	Scores generated based on food groups consumed by household	Continuous variable	(Danso-abbeam <i>et al.</i> , 2021)
Food security status	Adequate number of calories consumed compared by minimum dietary energy requirement (MDER)	(Food secure =1, otherwise = 0)	(Ibok <i>et al.</i> , 2019)
Household dietary quality Index	Index created by employing 9 macro and micronutrients and compared with recommended nutrient intake	(Adequate consumption of macro and micronutrients = 1, otherwise = 0)	(Holland and Rammohan, 2019)
Community Predictors (N=19)			
Basic Health Units	Number of health facilities available in a community (private pharmacy/drugstore, doctor, lady health worker, private clinic, trained midwife, public dispensary, basic health unit, traditional healer, traditional birth attendant etc)	A community in which above 15 health facilities were present was considered healthy community (Continuous)	(Scaramozzino, 2006)
Educated Community	Proportion of women with secondary or higher education in a community	A community in which at least 5% of women are educated (secondary or above) is considered as educated community (Yes =1, No = 0)	(Kamanda <i>et al.</i> , 2016), (Savari <i>et al.</i> , 2020)
Number of schools in community	Primary schools, lower secondary, secondary, and upper secondary schools	Continuous variable	(Scaramozzino, 2006)
Number of improved infrastructures in community	Improved road, bridge, market, water supply, electricity, and irrigation conditions in last year	Continuous variable	(S. Sharaunga <i>et al.</i> , 2015), (Eshetu and Guye, 2021)

*HH = head of household

Within these domains, different questions are underlying that are used in measuring the domains. Scores of indicators under each sub-domain were summed up and a cut-off of 30% was used as a threshold level in order to identify an empowered woman in each sub-domain. Similarly, scores of different sub-domains were summed up and a cut-off 30% was used to identify an empowered woman in each domain. Then, a binary variable was generated for each domain by assigning a value of "1" if a woman is empowered in a particular domain, otherwise "0". Lastly, an index was constructed using factor analysis and unequal weights were assigned to each domain based on the factor loadings. Factor analysis is preferable over other techniques due to the binary nature of domains (Pearson, 1900). Moreover, tetrachoric correlation was used, which is an improved measure of correlation for binary variables (Uebersax, 2000; Stata, 2013). Hence, the index encapsulated common information of all domains by avoiding redundancy and minimizing statistical biases.

Control Variables: In addition to RWCEI, several other control variables related to socio-demographic indicators of household and community level have been used in the statistical analysis. A list of all the control variables with their description along with literature support is provided in Table 2.

Econometric Estimation Method: We used multi-level mixed effect ordered logistic regression to determine the link between rural women's empowerment and HVFI. This method is used because our research is based on the premise that households are nested inside communities, and it offers fixed effects that are homogeneous among communities as well as random effects that capture variations across communities. The ordered logit model is used because the dependent variable is a low to a high categorical variable, in which "0" indicates high vulnerability and "2" represents no vulnerability. Table 4 presents the empirical findings by using RWCEI as a key independent variable along with other control variables and HVFI as dependent variable. Marginal effects are computed for this study by using the third response category as we are interested in the non-vulnerability of household food insecurity.

RESULTS

Descriptive statistics: Table 3 shows the descriptive statistics for the sampled households and communities. Results indicate that 33% of households are facing high vulnerability to food insecurity, and 14% facing mild vulnerability. Women's empowerment varied across the different domains. Whilst the majority of the women in our sample are empowered in allocating time for themselves, can go independently in/out their settlements and are not facing domestic violence, they lack empowerment in financial terms and in education. Household characteristics show that average age of head is 47, and only 4% are female-headed households

in the sample. Moreover, we have found that 51% of households are doing agricultural farming and approximately 50% of households are not consuming adequate calories, macro-nutrients, and micro-nutrients.

Multilevel Mixed Effect Ordered Logistic Regression: We use multi-level mixed effect ordered logistic regression to evaluate the impact of rural women's empowerment in mitigating the risks related to food insecurity. Results are presented in Table 4. Three multi-level ordered-logistic regression models are fitted. First, the null model (Model 1) is calculated without including any household or community level predictors. It incorporates community-specific random effects and partitions the total variance in non-vulnerability. The variance is significant across the communities ($\tau = 1.239$, $\rho = 0.01$). It indicates that differences in communities are explaining the likelihood of decreasing vulnerability to some extent. As shown by the variance partition coefficient (VPC), the intra-community correlation indicates that 23.9% of variation in non-vulnerability is explained by variation between communities and remaining 76.1% is attributable to variation between households. The second model contained household predictors in addition to community-specific random effects and their slopes were allowed to vary in order to explore their effects across communities (Model 2). The third model comprises both household level and community level predictors in addition to community-specific random effects (Model 3).

Women's empowerment as measured using the RWCEI enhances the chance of non-vulnerability and aids in lowering the risks of food insecurity at household level according to Model 2 and Model 3, since the variable is statistically significant and has a positive association in both models. Our results provide empirical evidence that probability of reducing vulnerability increased with rural women's empowerment by 9.6 % and 8.4% in both models, respectively. It means that empowered rural women can play a pivotal role in mitigating the risks of household food insecurity.

Our results demonstrate that there is 8.5% and 7.8% probability of increasing non-vulnerability to food insecurity for female-headed families in both models respectively. Similarly, the household head's age has a substantial impact in lowering the HVFI. Our findings indicate that when a person's age grows by one year, the likelihood of receiving non-vulnerability status increases. Table 4 shows, as number of family members or children increases or there is increase in dependency ratio, the probability of HVFI increases by 1.0% and 2.5% and 1.0% respectively.

The employment of the head of household plays significant role in mitigating the risks on household food insecurity. Results from models 2 and 3 suggest that, with an employed household head there are 10.4% and 9.4% more chances of reducing vulnerability, respectively. An employed person has more income to spend money on purchasing food items to

meet household's dietary requirements. Similarly, household wealth had a positive and significant impact on HVFI. In our case results show that richest households have 20.6% and 17.3% higher probability of experiencing non-vulnerability status which is more than middle income and poor households. Our analysis presents empirical evidence that participation in safety net programs may help in reducing the problems of experiencing food insecurity. Our findings show

that by participating in safety net programs, the probability of experiencing non-vulnerability increases by almost 10% than without participation.

Our findings also demonstrate positive and significant relationship with agricultural employment of household. Results indicate that, households involved in agricultural occupation has 5.6% and 4.4% more, probability of reducing the resilience towards HVFI.

Table 3. Summary statistics of the sample households (n=1866) and communities (n=19)

Variables	Mean	Std. Dev.	Min	Max	Freq.	Percentage
<i>Dependent Variable VHFII</i>						
VHFII	2.191	0.906	1	3		
Highly vulnerable to food insecurity	0.333	0.472	0	1	627	33.33
Mild vulnerable to food insecurity	0.142	0.349	0	1	268	14.25
Not vulnerable to food insecurity	0.524	0.499	0	1	986	52.42
<i>Rural Women Composite Empowerment Index (RWCEI)</i>						
Women Empowerment	0.774	0.168	0	0.99968		
Economic Empowerment	0.061	0.239	0	1	124	6.11
Autonomy	0.735	0.442	0	1	1,491	73.48
Decision Making	0.588	0.492	0	1	1,193	58.80
Qualification	0.031	0.172	0	1	62	3.06
Time Allocation	0.907	0.290	0	1	1,841	90.73
Mobility Empowerment	0.926	0.262	0	1	1,879	92.61
Political Empowerment	0.272	0.445	0	1	552	27.21
Awareness	0.128	0.334	0	1	259	12.76
Violence ⁵ (disempowerment)	0.889	0.314	0	1	1,804	88.91
<i>Household Level Predictors</i>						
Female headed households	0.046	0.209	0	1	94	4.61
Age of HH head	47.416	13.392	19	94		
Household Size	7.263	3.324	2	37		
Number of children in HH	3.933	2.557	0	26		
HH Head employment status (Employed)	0.844	0.363	0	1	1587	84.37
Agriculture employment (Yes)	0.515	0.499	0	1	1049	51.47
Non-farm employment (Yes)	0.101	0.301	0	1	205	10.06
Dependency Ratio	1.191	3.491	0.004	81		
Total land (Acres)	1.793	4.949	0	90.006		
Wealth Index						
Poorest	0.250	0.433	0	1	471	25.04
Poorer	0.247	0.432	0	1	465	24.72
Middle	0.252	0.434	0	1	474	25.20
Rich	0.251	0.434	0	1	473	25.15
Participation in social safety net programs	0.285	0.452	0	1	581	28.51
Household food expenditures	5.537	0.773	1.168	8.462		
<i>Food and Nutrition Security Predictors</i>						
Food Consumption Scores	67.01	14.085	5.5	107		
Food security status	0.524	0.499	0	1	987	52.42
Household Dietary Quality Index	0.505	0.500	0	1	950	50.51
<i>Community level predictors</i>						
Basic Health Units	17.792	12.422	3	49		
Educated Community	0.436	0.496	0	1	821	43.62
Number of schools in community	0.438	0.496	0	1	818	43.79
Number of improved infrastructures in community	0.496	0.500	0	1	927	49.57

Table 4. Results from multi-level mixed effect ordered logistic regression

⁵This domain operates in the inverse direction, increasing to indicate the disempowerment level of a woman. Therefore in order to make a direct relationship with women empowerment we took women who didn't face domestic violence in this domain.

Variables	Model 1	Model 2	Model 3
	(Null Model)	(Individual level Characteristics)	(Community level characteristics)
	ME (SE)	ME (SE)	ME (SE)
Fixed Effects			
Women Empowerment Index (RWCEI)		0.096 (0.058)*	0.084 (0.052)*
Household Predictors (N=1868)			
Sex of household head (Female = 1, Male = 0)		0.085 (0.047)*	0.078 (0.042)*
Age (Head)		0.009 (0.0008)***	0.008 (0.001)***
Family size		-0.0096 (0.005)*	-0.008 (0.005)***
Number of children in household		-0.025 (0.006)***	-0.022 (0.006)***
Household head employment (Yes =1, No =0)		0.104 (0.031)***	0.094 (0.028)***
Agriculture employment (Yes = 1, No = 0)		0.056 (0.024)**	0.044 (0.022)**
Non-farm employment (Yes = 1, No = 0)		0.019 (0.037)	0.021 (0.033)
Dependency ratio		-0.009 (0.003)***	-0.008 (0.003)***
Total land (Acres)		0.012 (0.003)***	0.009 (0.003)***
HH Wealth Index			
Poor		-	-
Middle		0.057 (0.027)**	0.045 (0.024)*
Rich		0.105 (0.029)***	0.083 (0.028)***
Richest		0.206 (0.034)***	0.173 (0.034)***
Participation in social safety net programs (Yes =1, No = 0)		0.106 (0.022)***	0.097 (0.022)***
Food expenditures (log)		0.047 (0.019)**	0.034 (0.017)**
Food and nutrition security predictors			
Food Consumption Scores		0.003 (0.0007)***	0.003 (0.0007)***
Food security status (Food secure =1, otherwise = 0)		0.076 (0.028)**	0.062 (0.025)**
Household dietary quality Index (adequate consumption of macro and micronutrients = 1, otherwise = 0)		0.052 (0.028)*	0.045 (0.025)*
Community Predictors (N=19)			
Basic Health Units (Numbers)			0.005 (0.003)*
The proportion of women with secondary or higher education in a community (Educated Community)			0.139 (0.072)**
Number of schools in community			0.042 (0.025)*
Number of improved infrastructures in community			0.036 (0.021)*
Region of Residence			
Punjab			0.103 (0.155)
Sindh			0.144 (0.173)
KPK			1
Random Effects			
Community Level	1.239 ***	1.028 ***	1.671 **
Variance (SE)	(0.423)	(0.365)	(0.713)
VPC/ICC (%)	23.9	17.7	22.9
Model Fit Statistics			
AIC	4496.105	4215.099	4176.12
Wald chi2	-	263.07	268.69
(Prob > chi2)	-	0.000	0.000
Log-Likelihood	-1624.3664	-1459.6533	-1437.0625

Note: "ME" indicates the marginal effect of the variable on the probability of the third outcome of the dependent variable, which is supportive of the non-vulnerability to household food insecurity. AIC= Akaike Information Criteria.

* = p < 0.1, ** = p < 0.05, *** = p < 0.01

Our findings show that with each unit increase in food expenditures, the probability of having non-vulnerability to food insecurity increases by 4.7% and 3.4% in both models, respectively. Similarly, Table 4 also shows that as food and nutrition of household improves in terms of caloric intake, food diversity and adequate consumption of macro and micronutrients, HVFI decreases. Agricultural land is of huge significance in rural areas of Pakistan and considered as decisive factor in crop production. This in turn determines the resilience towards household's food insecurity. Our study also highlights that, as land size increases, vulnerability to food insecurity decreases. With the introduction of community level predictors in the third model we introduce contextual variations in our analysis. Our findings demonstrate that communities with basic health facilities and improved infrastructures, like improved roads, market facilities, water supply, electricity and irrigation facilities help in reducing the vulnerabilities towards food insecurity. Similarly, education is associated positively and significantly in mitigating the vulnerability.

In comparison to Model 1, the variation in non-vulnerability to food insecurity in Model 2 ($\tau=1.028$, $\rho=0.01$) and Model 3 ($\tau=1.671$, $\rho=0.05$) also remained significant across communities, with VPC 17.7% and 22.9 %, respectively. These results indicate that community variations in the likelihood of non-vulnerability are partly due to the composition of the communities by community-level characteristics. Successively, lower values of Akaike Information Criterion (AIC) with each subsequent model indicates that each model improves significantly from the previous model. It also demonstrates the goodness of fit of the respective model employed in the present analysis.

We also performed robust analysis to examine the impact of some different assumptions on our analysis. We adopted two approaches for sensitivity and uncertainty analysis: one-at-a-time approach that used alternative data type of dependent variable (i.e., continuous scores instead of categories) and a model discrimination approach that dropped crucial control covariates to examine their impact in analysis (Ibok *et al.*, 2019). We found that execution of original ordinal logistic regression is superior to linear one and we compared AIC values between original and reduced models, and we investigated that original model performed better with all crucial covariates, as AIC values are lower in these models (See Appendix).

DISCUSSION

In developing countries like Pakistan, food insecurity and the uncertainties relating to food acquisition are major concerns for policy makers. There are different risk factors with which rural people are confronting with. This current study investigated the influence of rural women's empowerment on vulnerability to food insecurity to mitigate these shocks. The

importance of women's autonomy and authority in reducing the impact of risks on food security is a little researched area in the literature. Rural women act as food producers, income earners, natural resource managers, and caregivers for household food and nutrition security. Empowering them is intrinsically related to building food systems and combating hunger and malnutrition. Our study aims to direct researchers and policymakers dealing with food insecurity and its vulnerability issues by providing empirical evidence and a comprehensive way of measuring empowerment of women. While measuring women's empowerment we focused on using maximum dimensions instead of using proxy variables for it. To the best of knowledge, this is the first study to explicitly demonstrate that causal link between female empowerment and HVFI.

Women in rural areas play a variety of important roles in the food production and preparation processes, as well as serving as agricultural entrepreneurs who dedicate their lives to ensuring the food and nutritional security of their families and communities, as well as the continuity of food supply in times of economic distress (Galié, 2013; Das and Singh, 2020). Das and Singh (2020) stated that empowering rural women is critical for ensuring self-reliance and avoiding risks towards shocks in the future. Our findings indicate that women's empowerment is a key determinant of vulnerability to food insecurity. Moreover, it is also evident from the previous studies that empowerment of rural women in all aspects, economic, political, social, familial, psychological and legal capabilities can help to achieve sustainable livelihoods (Das and Singh, 2020).

The age of the household head also plays an essential role in minimizing vulnerabilities, since as individuals become older, they accumulate assets, gain experiences, and adopt appropriate techniques to deal with shocks, making their household less vulnerable to food insecurity (Mthethwa and Wale, 2021). Furthermore, there is a possibility of receiving a pension and other advantages of old age, meaning that this awareness and accumulated resources enable households to build resilience to the vulnerabilities that arise with shocks, and they begin investing for a better way of life.

In terms of economic empowerment, women require a sense of physical, capital, and economic agency to improve the food security status of their households. Women with more financial resources are better equipped to establish and achieve their own goals. It is the most crucial part of women's empowerment since it provides them with the 'motivation' to effectively utilise resources to secure self-sufficiency and improved living conditions. Access to, and control over, physical capital resources result in increased agricultural output and off-farm income options. They also help households to diversify their incomes, providing food security (Sharaunga *et al.*, 2016).

Female-headed households consume more food in terms of calories than male-headed households (Azeem *et al.*, 2016).

In contrast, when families grow, there are more non-working members being fed by a small number of working members. This means that there are more mouths relying on limited income to live; less savings for future investment; and eventually reduced resources and food consumption per capita (Tawodzera, 2011; Sharaunga *et al.*, 2015). Our findings are consistent with the food availability hypothesis of migration, which holds that as family size grows, food availability declines, resulting in decreased resilience to food insecurity and therefore increased vulnerability (Eshetu and Guye, 2021).

Agriculture is an important occupation for rural households because families who are involved in agricultural farming can easily grow different types of fruits and vegetables at farms and ultimately have more opportunities to get diversified and easily accessible food than persons who are involved in non-farm employment. Therefore, improved farm management skills are important for running agricultural occupation. It ensures high agricultural output, increases adaptability to mitigate the risks from food related shocks, ultimately ensures household food security in rural areas. Furthermore, Aziz *et al.* (2020) investigated that, households involved in agricultural occupation had good food choices. They spend their agricultural income on purchasing food items and investing in high quality food and make more food expenditures.

As the wealth and food expenditures increases, there are less chances that households experience food insecurity and hence risks towards food insecurity also reduces. Our results are aligned with Harris-Fry *et al.* (2015) study, which shows that at lower levels of household wealth only basic necessities are fulfilled and as wealth increases people start spending on healthy food items and better lifestyles. Incomes of households are considered as the most significant determinant of food security. Therefore, improving income opportunities for rural women can improve household food security.

As it is evident from literature that communities play a pivotal role in shaping the societies. As improved infrastructure facilitates the whole process of food production from input market purchases to output market sales. Basic health units can help create awareness among people about healthy eating practices and help in dealing with the illness caused by hunger and malnutrition. This in turn may reduce the risks of health shocks towards food insecurity. The hypothesis is that an educated community improves the knowledge about adopting the nutrient rich food and how to save money for healthy consumption patterns for family. This result is consistent with Kamanda *et al.* (2016) and Woldemicael and Tenkorang (2010), which state that with an increase in the proportion of mothers' education in the community, maternal and children's health seeking behaviour improves, which in turn helps in reducing the resilience towards food insecurity.

Aside from its impact on food insecurity, women's empowerment is especially important for women's mental and

physical well-being, and for women who have been left alone due to divorce, a husband's departure, or death. Empowering women across the domains of education, economics, and decision-making allows them to live a self-sustaining existence in the event of difficult circumstances and may allow independence from her parents or her husband's parents.

Conclusions and Policy Implications: It is crucial to understand the complex associations between food security and multiple domains of women's empowerment. Women's empowerment has a positive and significant impact on reducing the household vulnerability to food insecurity, alongside other factors such as age of head of household, access to a safety net program, and community infrastructure such as basic health facilities, schools, and transport. Empowering women therefore needs to be embedded in any policy solutions to address food insecurity, especially in rural areas of Asia.

Measures such as the rural women composite empowerment index (RWCEI) can aid both policymakers and researchers gain a more nuanced picture of the domains where policy solutions are needed, saving time and resources. The index can also be used to track progress once solutions are introduced. In this study, the main areas of disempowerment were economic decision making and education, but this may not be the same in different contexts (for example in urban areas).

Our findings lend credence to policies/programs/efforts aimed at encouraging and promoting women's empowerment. The present study proposed some key recommendations to strengthen the status of rural women in Pakistan. First, provision of paid jobs and access to credit should be emphasized while designing policies. Second, educational opportunities in terms of different programs and vocational trainings need to be introduced. Last, there is a need of time to reshape the community's thinking about women's empowerment, for example through public awareness campaigns.

Limitations of the study: Our work has a few limitations; each one opens new avenues for future investigation. First, the results presented here are based on PRHPS data from 2014. The reason for using this data is that it contains a significant amount of data about women's empowerment and household FNS characteristics. Although this unique sort of data has not yet been updated, there are other surveys that include variables on similar themes, but they are not comprehensive enough to encompass and cover all areas (especially in case of women empowerment). If the data is updated, future research can be undertaken to aid policymakers understand the link between women's empowerment and FNS. Second, the sampled data is limited to three provinces in rural Pakistan, necessitating larger-scale study (covering all provinces' rural areas) in order to generalise the findings. Third some underlying assumptions were made about the cut off points for the data; whilst these

are based on previous literature, they are indicative rather than absolute. Therefore, if further research on women's empowerment is published, future studies may need to use revised cut off points.

Conflict of Interest: The authors declared no conflict of interest to report.

Authorship contribution statement: Sidra Ishfaq: Methodology, Software, Data curation, Formal Analysis, Writing-original draft and editing.

Abedullah Anjum: Supervision, Conceptualization, Methodology, Visualization and Validation. Shahzad Kouser: Supervision, Conceptualization Methodology and Writing-review & editing. Ruth Jepson: Supervision, Investigation, Writing review & editing, Visualization and Validation.

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Appendix

Robust Analysis: Sensitivity and Uncertainty analysis

A1- Model with dependent variable change:

Table A1: Model with one-at-a-time approach that used continuous scores of dependent variable

Variables	Model 1 (Null Model)	Model 2 (Individual level Characteristics)	Model 3 (Community level characteristics)
	β (SE)	β (SE)	β (SE)
Fixed Effects			
<i>Women Empowerment Index (RWCEI)</i>		1.131 (0.311)***	1.066 (0.304)***
<i>Household Predictors (N=1866)</i>			
Sex of household head (Female = 1, Male = 0)		0.464 (0.233)**	0.446 (0.229)**
Age (Head)		0.043 (0.004)***	0.042 (0.004)***
Family size		-0.055 (0.025)**	-0.050 (0.025)**
Number of children in household		-0.067 (0.032)**	-0.070 (0.031)**
Household head employment (Yes =1, No =0)		0.517 (0.148)***	0.528 (0.145)***
Agriculture employment (Yes = 1, No = 0)		0.189 (0.118)*	0.056(0.117)
Non-farm employment (Yes = 1, No = 0)		0.071 (0.189)	0.044 (0.186)
Dependency ratio		-0.032 (0.013)***	-0.031 (0.013)***
Total land (Acres)		0.096 0(.009)***	0.089 (0.009)***
HH Wealth Index			
Poor		1	1
Middle		0.256 (0.141) *	0.217 (0.139)
Rich		0.788 (0.150)***	0.685 (0.149)***
Richest		1.617 (0.165)***	1.521 (0.163)***
Participation in social safety net programs (Yes =1 , No = 0)		0.479 (0.109)***	0.481 (0.107)***
Food expenditures (log)		0.544 (0.070)***	0.449 (0.069)***
<i>Food and nutrition security predictors</i>			
Food Consumption Scores		0.014 (0.004)***	0.015 (0.004)***
Food security status (Food secure =1, otherwise = 0)		0.525 (0.135)***	0.469 (0.133)***
Household dietary quality Index (adequate consumption of macro and micronutrients = 1, otherwise = 0)		0.518 (0.137)***	0.463 (0.134)***
<i>Community Predictors (N=19)</i>			
Basic Health Units (Numbers)			0.062 (0.017)***
The proportion of women with secondary or higher education in a community (Educated Community)			2.177 (0.317)***
Number of schools in community			-0.018 (0.132)
Number of improved infrastructures in community			0.529 (0.114)***
Region of Residence			
Punjab		1.048 (1.121)	0.734 (1.680)
Sindh		1.012 (1.231)	1.424 (1.846)
KPK		1	1
Random Effects	Empty	Individual-level	Community-level
Community Level	3.126***	2.109**	4.789***
Variance (SE)	(1.031)	(0.699)	(1.728)
VPC/ICC (%)	37.0	35.6	56.9
Model Fit Statistics			
AIC	8551.563	7970.211	7845.827
Wald chi2	-	736.46	860.80
(Prob > chi2)	-	0.000	0.000
Log-Likelihood	-4272.7817	-3962.1056	-3895.9135

A2- Reduced Model:**Table A2: Model with discrimination approach that dropped crucial control covariates to examine their impact in the analysis**

Variables	Model 1 (Null Model)	Model 2 (Individual level Characteristics)	Model 3 (Community level characteristics)
	β (SE)	β (SE)	β (SE)
Fixed Effects			
Women Empowerment Index (RWCEI)		1.089 (0.319)***	1.059 (0.323)***
<i>Household Predictors (N=1866)</i>			
Food Consumption Scores		0.021 (0.004) ***	0.021 (0.004)***
Food security status (Food secure =1, otherwise = 0)		0.442 (0.147)***	0.418 (0.149)***
Household dietary quality Index (adequate consumption of macro and micro nutrients = 1, otherwise = 0)		0.506 (0.148)***	0.486 (0.150)***
<i>Community Predictors (N=19)</i>			
Basic Health Units (Numbers)			0.040 (0.020)**
The proportion of women with secondary or higher education in a community (Educated Community)			1.431 (0.551)***
Number of schools in community			0.296 (0.149)**
Number of improved infrastructures in community			0.418 (0.128)***
Region of Residence			
Punjab		0.819 (0.828)	0.522 (1.124)
Sindh		0.087 (0.905)	0.404 (1.243)
KPK		1	1
Random Effects	Empty	Individual-level	Community-level
Community Level	1.239***	1.132***	2.114**
Variance (SE)	(0.423)	(0.390)	(0.917)
VPC/ICC (%)	23.9	21.6	28.2
Model Fit Statistics			
AIC	4254.733	4207.062	4189.637
Wald chi2	-	57.39	80.22
(Prob > chi2)	-	0.000	0.000
Log-Likelihood	-1624.3664	-1594.5311	-1561.8187

Comparison of AIC Values:

	Original Model	Robust Model 1A	Robust Model 2A
AIC	4176.12	7845.827	4189.637

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