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Impact of armed conflict on food security and household nutrition in Sudan: a cross-sectional survey

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ABSTRACT

Background: Armed conflict in Sudan has severely disrupted food systems, affecting food availability, affordability, and household dietary quality. Understanding household perceptions of food access and price shocks is essential for informing humanitarian and policy responses.

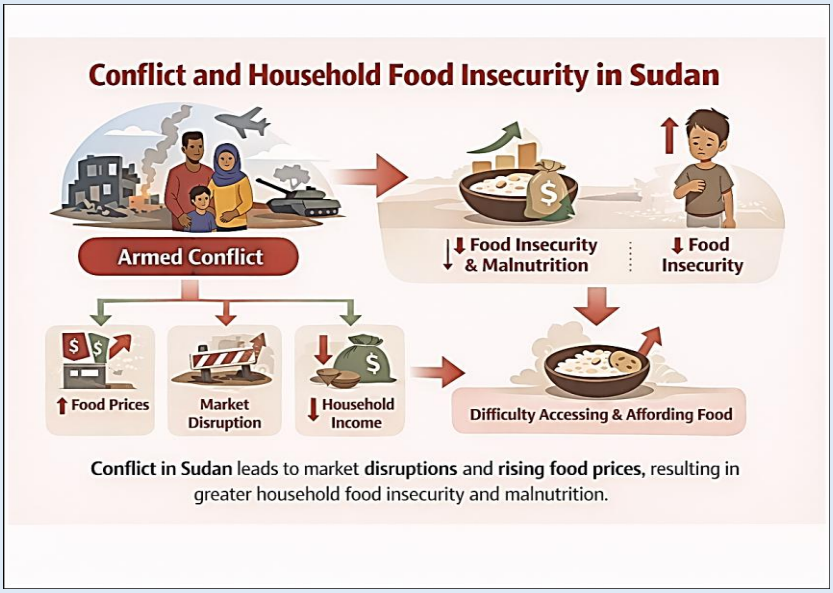
Objective: To assess the perceived impact of conflict-related food price increases and war-related barriers to food access on daily life and the ability to provide healthy, balanced meals, and to examine associations with key socio-demographic factors.

Methods: A cross-sectional survey was conducted in 2025 among 225 adults (≥18 years) residing in conflict-affected regions of Sudan. A structured questionnaire assessed employment status, perceived food price changes, war-related food access barriers, and difficulty providing healthy meals. Data were analyzed using descriptive statistics and Pearson's chi-square tests. Effect sizes were estimated using Cramer's V, with statistical significance set at $p \leq 0.05$.

Results: Most respondents were aged 18–30 years (73.4%). Overall, 85.3% reported that the food crisis negatively affected their daily life, and 84.9% indicated that war impaired their ability to access food. A large majority (82.2%) perceived that food prices had doubled. Unemployed individuals and homemakers were significantly more likely to report daily life disruption compared to employed respondents ($\chi^2 = 29.5$, $p < 0.001$, Cramer's V = 0.36). Households reporting doubled food prices were more likely to experience crisis-related disruption ($\chi^2 = 58.0$, $p < 0.001$, Cramer's V = 0.51). Nearly 90% of respondents reported either permanent or occasional difficulty in providing healthy and balanced meals. War-related barriers to food access were strongly associated with difficulty providing adequate diets ($\chi^2 = 31.5$, $p < 0.001$, Cramer's V = 0.37).

Conclusions: The ongoing conflict in Sudan has profoundly compromised household food access, dietary adequacy, and economic stability. Rising food prices and livelihood vulnerability significantly intensify the impact. Urgent multisectoral interventions focusing on market stabilization, livelihood restoration, and nutrition-sensitive humanitarian responses are essential to mitigate the escalating risk of food insecurity and malnutrition.

Novelty of the Study: This study provides an integrated assessment of how conflict-related food price increases and war-related barriers to food access are associated with household food insecurity in Sudan. Unlike prior studies that focus primarily on descriptive associations, this research empirically disentangles market disruption and income reduction effects, offering a clearer causal framework to inform targeted policy responses.



Graphical Abstract: Impact of armed conflict on food security and household nutrition in Sudan: A cross-sectional survey.

Keywords: Armed conflict; Food insecurity; Food prices; Household; Nutrition; Sudan; and War.

INTRODUCTION

Food insecurity is a multidimensional phenomenon shaped by environmental, economic, and political forces that intersect to undermine dietary quality, nutrient adequacy, and public health [1]. These challenges are further compounded by the intersections of climate change with food systems and nutrition, undermining both public health and the integrity of food systems [2]. Armed conflict remains among the most powerful drivers of these crises, disrupting agricultural production and destabilizing markets, which worsens food insecurity and compromises diet quality [3]. Recent evidence from active war zones suggests that such disruptions reduce food availability and affordability, leading to heightened anxiety and nutritional deterioration [4]. Global analyses highlight the need for nutrition-sensitive, evidence-based interventions in conflict-affected regions to address worsening food and nutrition insecurity [5]. In regions such as Sudan, prolonged political instability has led to the consumption of lower-quality foods that are often less diverse and nutritionally inadequate, thereby increasing household nutritional vulnerability [6]. Such chronic nutritional stress leads to cortisol dysregulation, a primary biomarker that correlates with sleep disturbances and diminished mental wellness in vulnerable populations [7]. Beyond the immediate caloric deficit, the lack of dietary diversity in conflict zones results in a significant reduction of antioxidant capacity, which is essential for combating oxidative stress induced by environmental trauma [8 - 10]. Sudan has experienced prolonged political instability and armed conflict, resulting in widespread displacement, market disruption, and rising food prices [11-14]. Evidence from conflict-affected settings shows that households often adopt coping strategies such as reducing meal frequency, consuming lower-quality foods, or skipping meals entirely [15-18]. Recent advances in functional food science emphasize the role of nutritional quality, dietary diversity, and bioactive-rich foods in promoting health and resilience under conditions of nutritional stress [1]. Functional foods, including those enriched with micronutrients, antioxidants, and plant-derived bioactive compounds, have been increasingly recognized as potential tools to mitigate the adverse effects of food insecurity [7]. Evidence from recent studies within the Functional Food Science and FFHDJ ecosystem highlights the importance of integrating nutritional quality with food security interventions to enhance health outcomes, particularly in vulnerable and conflict-affected populations [3]. Understanding how households perceive and experience these disruptions is essential for designing effective interventions. This study assesses the perceived impact of conflict-related food price increases and war-related barriers to food access on daily life and household nutrition in Sudan and examines associations with sociodemographic factors.

MATERIALS AND METHODS: Study Design and Limitations: This study employed a cross-sectional survey design using convenience sampling in conflict-affected regions of Sudan. While this design is widely used in humanitarian and nutrition research for rapid assessment of food security in crisis settings [19-20], the use of non-probability sampling limits generalizability due to potential selection bias. Several limitations should be acknowledged. The absence of gender-specific and subgroup analyses restricts the ability to explore differential impacts across population groups, while the underrepresentation of children limits the interpretation of age-related vulnerabilities. In addition, reliance on self-reported data may introduce recall and social desirability bias. Furthermore, the cross-sectional nature of the study prevents causal inference between conflict exposure and food insecurity outcomes. Despite these limitations, the study provides valuable contextual evidence on household food security and dietary conditions in Sudan during armed conflict, supporting humanitarian and policy responses.

Conflict-affected regions: The study was conducted in areas of Sudan experiencing ongoing armed conflict, characterized by population displacement, disrupted livelihoods, restricted market access, and weakened food systems. These conditions are consistent with humanitarian descriptions of conflict-affected settings commonly used in nutrition and food security research.

Sampling methodology: A convenience sampling technique was used due to security constraints, population displacement, and the absence of a reliable sampling frame in the study areas. Participants were recruited based on accessibility and willingness to participate during the data collection period. While this approach enabled rapid data collection under unstable conditions, it may introduce selection bias and limit the generalizability of the findings to the broader population in conflict-affected regions of Sudan.

Study population and sample size: A total of 225 adults aged ≥18 years were recruited using convenience sampling. This sample size was considered sufficient for the descriptive and chi-square analyses used in this study [19].

Data collection instrument: A structured questionnaire was administered by trained data collectors. The questionnaire included items on:

- Sociodemographic characteristics
- Perceived impact of the food crisis
- War-related barriers to food access
- Perceived food price changes
- Difficulty providing healthy meals

Study variables:

Dependent variables:

- Perceived impact of the food crisis on daily life
- Difficulty providing healthy and balanced food
- Independent variables:
- Employment status
- Perceived food price changes
- War-affected food access

These variables reflect well-established pathways through which conflict influences food insecurity, as documented in multiple conflict settings [20].

Statistical Analysis: Data were analyzed using SPSS v24. Frequencies and percentages summarized categorical variables. Associations were assessed using Pearson's chi-square test, with significance set at $p \leq 0.05$. Cramer's V quantified effect size, consistent with recommended practices for categorical data analysis [21]. Assumptions for chi-square tests were verified using minimum expected cell counts ≥5 [22].

Ethical Considerations and Informed Consent: Participation was voluntary, and verbal informed consent was obtained from all respondents prior to data collection. The use of verbal rather than written consent is scientifically and ethically justified in this context to ensure participant protection. In active conflict settings, participants often fear that signing formal documents may link their identity to specific socio-economic or political viewpoints; verbal consent ensures complete anonymity and mitigates protection risks [23]. This methodology aligns with the WHO ethical standards for research in humanitarian and conflict settings, which acknowledge that written documentation can be culturally inappropriate or pose safety risks to subjects in unstable environments [24].

RESULTS

The analysis included 225 respondents, with the majority being young adults aged 18–30 years (73.4%). Those aged 31–50 years accounted for 22.2% of the sample, while respondents under 18 years and over 50 years made up small proportions (Table 1) (1.3% and 3.1%, respectively).

Table 1. Age distribution of surveyed respondents (n = 225).

Age group (years)	Frequency (n)	Percentage (%)
< 18	3	1.3
18–30	165	73.4
31–50	50	22.2
> 50	7	3.1
Total	**225**	**100.0**

Table 2. Association between employment status and perceived impact of the food crisis on daily life (n = 225).

Employment status	Crisis affected daily life: Yes	Crisis affected daily life: No/Other	Total
Unemployed / Homemaker	115 (51.1%)	4 (1.8%)	119 (52.9%)
Employed	77 (34.2%)	29 (12.9%)	106 (47.1%)
Total	**192 (85.3%)**	**33 (14.7%)**	**225 (100.0%)**

***Footnote**: Values are presented as n (%). Association was tested using Pearson's chi-square test.*

χ^2 (1) = 29.5, p < 0.001.

Effect size: Cramer's V = 0.36 (moderate association). Minimum expected cell count = 6.2; chi-square assumptions were met.

Overall, 85.3% of respondents reported being affected by the food crisis in their daily lives. The perceived impact varied significantly based on employment status (Table 2). Among the unemployed and homemakers, 51.1% indicated that the crisis affected their daily life, compared to 34.2% among employed respondents. This difference was statistically significant (χ^2 (1) = 29.5, p < 0.001), with a moderate effect size (Cramer's V = 0.36).

Table 3: Perceived Impact of Food Crisis and War-Related Barriers to Food Access (n = 225).

Response category	Food crisis affecting daily life	War affects the ability to access food
Yes, significantly	71 (31.6%)	77 (34.2%)
Yes, moderately	134 (59.6%)	114 (50.7%)
No / no direct impact	12 (5.3%)	30 (13.3%)
Other*	2 (0.9%)	2 (0.9%)
Missing	6 (2.7%)	2 (0.9%)
Total	**225 (100.0%)**	**225 (100.0%)**

* "Other" includes unclear or qualitative responses.

Table 3 presents the perceived impact of the food crisis on daily life and the barriers to food access related to the ongoing war. The data are based on responses from 225 participants. The food crisis and war were perceived to have a substantial impact on daily life and food access. Over 90% of respondents stated that the food crisis affected their daily life, with 31.6% reporting a significant impact and 59.6% reporting a moderate impact. Similarly, 84.9% indicated that war negatively affected their ability to access food, with 34.2% reporting a significant impact and 50.7% reporting a moderate impact. Only a small percentage of respondents reported no direct impact of either the food crisis or war on food access.

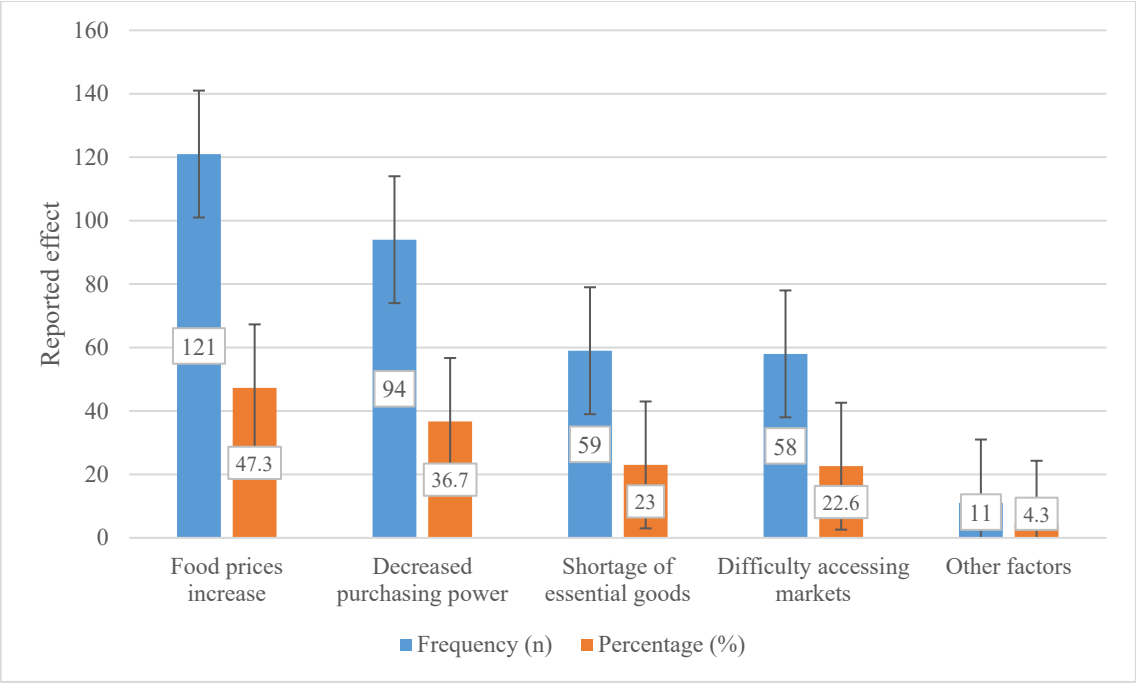


Figure 1. Effects of War on Household Food Access (n = 225)

Based on 256 responses from 191 participants, percentages may exceed 100% due to multiple responses. War impacts food access through several mechanisms, including food price hikes (47.3%), reduced purchasing power (36.7%), shortages of essential goods (23.0%), and limited access to markets (22.6%), indicating a multifaceted crisis (Fig. 1).

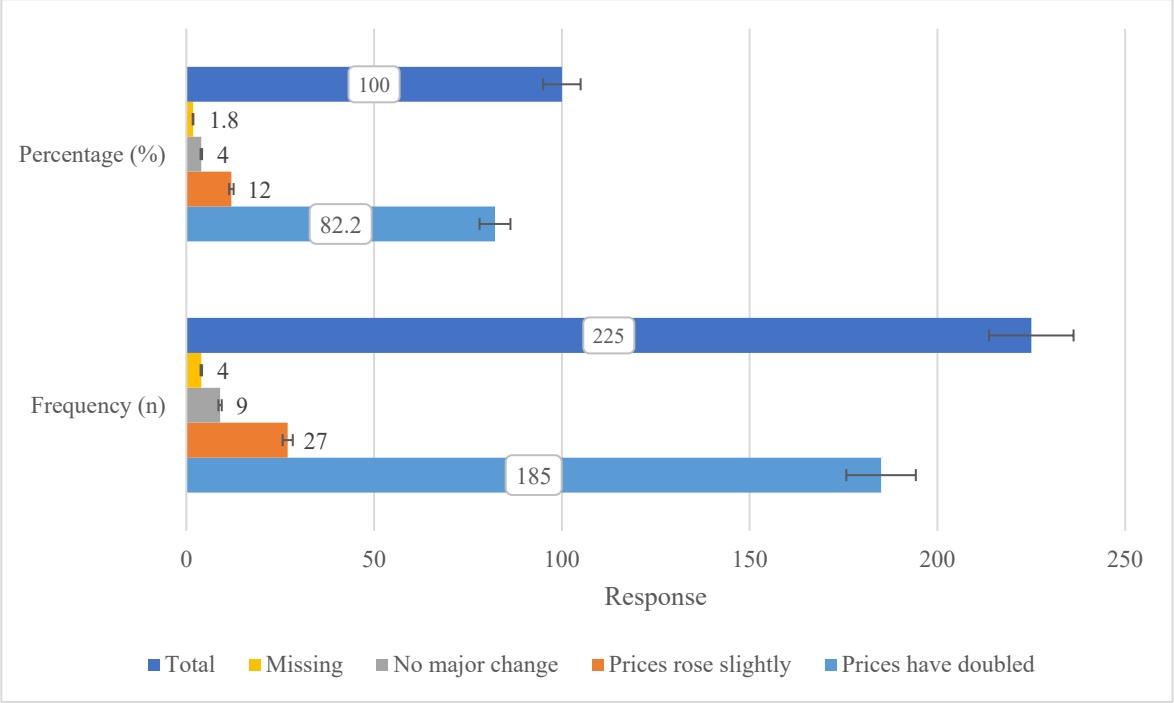


Figure. 2. Perceived Impact of Conflict on Household Food Prices (n = 225). The perceived effect of conflict on food prices was substantial, with the majority of respondents (82.2%) reporting that food prices had doubled. Additionally, 12.0% reported slight price increases, while only 4.0% perceived no major change in food prices.

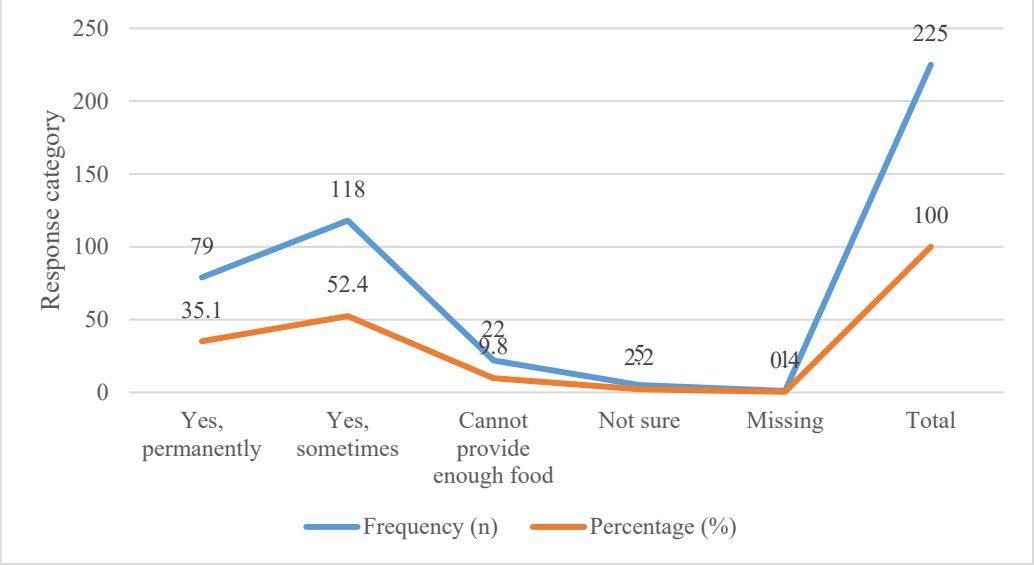


Figure 3. Difficulty in providing healthy and balanced food during conflict (n = 225).

During the conflict period, households experienced substantial difficulties in providing healthy and balanced meals. As illustrated in Fig. 3, 35.1% of respondents reported permanent difficulty, while 52.4% faced occasional challenges. In addition, 9.8% were unable to provide sufficient food, indicating severe levels of food insecurity.

Table 4. Association between perceived food price changes and the impact of the food crisis on daily life (n = 225).

Food price change	Crisis affected daily life: Yes	Crisis affected daily life: No/Other	Total
Prices have doubled	175 (77.8%)	10 (4.4%)	185 (82.2%)
Moderate / no change	17 (7.6%)	23 (10.2%)	40 (17.8%)
Total	**192 (85.3%)**	**33 (14.7%)**	**225 (100.0%)**

Values are presented as n (%). The association was tested using Pearson's chi-square test.

There was a strong association between perceived food price changes and the impact of the food crisis on daily life. Specifically, 77.8% of respondents who reported that food prices had doubled indicated that the crisis affected their daily life significantly (χ^2 (1) = 58.0, $p < 0.001$, Cramer's V = 0.51).

Table 5. Association between war-affected food access and difficulty providing healthy food at the household level (n = 225).

Difficulty providing healthy food	War affected access: Yes	War affected access: No/Limited	Total
Yes	185 (82.2%)	20 (8.9%)	205 (91.1%)
No / not sure	6 (2.7%)	14 (6.2%)	20 (8.9%)
Total	**191 (84.9%)**	**34 (15.1%)**	**225 (100.0%)**

Values are presented as n (%). Association was tested using Pearson's chi-square test.

χ^2 (1) = 31.5, $p < 0.001$.

Effect size: Cramer's V = 0.37 (moderate association).

Minimum expected cell count = 9.0; chi-square assumptions were met.

War-affected food access and dietary adequacy

Difficulty providing healthy food was strongly associated with war-related barriers to food access (Table 5). Among respondents affected by war-related food access barriers, 82.2% had trouble providing healthy food, compared to 8.9% among those with no or limited war-related access barriers. This association was statistically significant (χ^2 (1) = 31.5, $p < 0.001$) with a moderate effect size (Cramer's V = 0.37).

DISCUSSION

The findings of this study indicate that the ongoing armed conflict in Sudan has substantially disrupted household food security, dietary quality, and daily functioning [25]. The high proportion of respondents reporting that the food crisis affected their daily lives (85.3%) reflects the widespread vulnerability of households exposed to conflict-related economic and market instability [26]. These impacts are consistent with evidence that armed conflict is a major driver of food insecurity through disruptions to food systems, infrastructure damage, and restricted mobility [16]. The main pathways observed in this study include food price inflation, reduced purchasing power, and limited market access, which collectively reduce food availability and affordability [27]. A key finding of this study is the strong perception of a doubling of food prices (82.2%), highlighting severe market disruption during the conflict [28]. This economic shock was significantly associated with reported household food insecurity, indicating that price instability is a central transmission pathway linking conflict to nutrition outcomes [29]. Similarly, unemployment was strongly associated with higher perceived crisis impact, emphasizing the role of income insecurity in limiting access to food [30]. These findings are consistent with evidence from conflict-affected populations, where income loss and livelihood disruption significantly increase the risk of food insecurity [16]. The majority of respondents (approximately 90%) reported difficulty providing healthy, balanced meals, indicating a marked deterioration in dietary quality [31]. These findings suggest a shift toward less diverse and nutrient-poor diets driven by affordability constraints and reduced food availability. Such dietary compromises increase the risk of micronutrient deficiencies and adverse health outcomes, particularly among vulnerable groups such as women and children [32]. Beyond economic effects, the findings suggest broader psychosocial consequences of food insecurity [33]. High levels of food access difficulties may contribute to stress and reduced household resilience, although this was not directly assessed in the present study [34]. In addition, the interaction between conflict and climate-related shocks may further exacerbate food system instability in Sudan, intensifying existing vulnerabilities [14]. Recent research on Sudan's current war and earlier crises shows that conflict-driven food insecurity is largely transmitted through collapsed economic activity and disrupted markets, rather than simple local food shortages [35]. These findings underscore the urgent need for interventions to stabilize food prices, strengthen household income sources, and implement nutrition-sensitive humanitarian programs to mitigate the growing burden of food insecurity [36].

Functional Food Science and Nutritional Resilience in Conflict-Affected Frameworks: The profound disruption of daily life reported by 85.3% of respondents can be scientifically contextualized through the "Selfish Brain Theory." During acute nutritional stress, the central nervous system prioritizes its own energy demands at the expense of peripheral organs, leading to cognitive exhaustion and impaired concentration observed in this study [3]. This metabolic shift involves a transition from gluconeogenesis to lipid oxidation, often resulting in metabolic acidosis and long-term physiological damage [3]. Furthermore, the vulnerability among unemployed individuals and homemakers suggests a cycle of physiological and economic stress. Chronic food insecurity acts as a potent stressor that triggers cortisol dysregulation, which is intricately linked to sleep disturbances and diminished mental health [7]. This hormonal imbalance likely exacerbates household vulnerability by undermining the capacity to manage resources or seek livelihoods. The inability of nearly 90% of households to maintain balanced diets represents a critical loss of dietary bioactive compounds. At the crossroads of armed conflict and nutrition insecurity, the deficit of antioxidants and plant-derived bioactives—essential for mitigating conflict-induced oxidative

stress—poses a threat that exceeds basic caloric deficiency [1]. Consequently, interventions must move beyond basic aid toward functional food-based solutions that prioritize the restoration of nutritional quality and physiological resilience [1, 7].

FFC 17-Step Framework in Population-Level Nutrition Research: This study aligns with selected components of the Functional Food Center (FFC) 17-step framework that relate to population-level nutrition research rather than functional food development. It corresponds strongly to Step 11 (scientific publication) by contributing peer-reviewed evidence on food insecurity in conflict settings, and Step 16 (epidemiological studies) by generating cross-sectional data on conflict-related impacts on food access and dietary quality. The findings also support Step 12 (education of stakeholders) by informing policymakers, humanitarian agencies, and public health actors about the severity of food insecurity, and Step 13 (policy communication) by providing evidence to guide decision-making and emergency responses. Additionally, Step 17 is indirectly reflected through the need for ongoing population-level monitoring of nutrition conditions in conflict-affected areas. Overall, the FFC framework is applied here in an adapted form, extending its relevance from functional food regulation to broader epidemiological and policy-oriented nutrition research in humanitarian contexts.

Recommendations: To address food insecurity in conflict-affected areas of Sudan, efforts should focus on enhancing food system resilience by stabilizing food prices and ensuring market functionality. Targeted social protection and humanitarian assistance programs should be expanded to support economically vulnerable households and improve access to nutritious food. Nutrition-sensitive interventions should also be integrated into emergency responses to improve dietary quality and help prevent long-term health consequences. In addition, livelihood support programs are needed to restore household incomes and strengthen resilience, while regular monitoring of food security indicators is essential to guide timely, evidence-based interventions. This study contributes to the current understanding of conflict-related food insecurity by highlighting the roles of market disruption, income insecurity, and barriers to food access in shaping household experiences during armed conflict. The findings indicate that stabilizing markets and protecting household purchasing power are important intervention points for mitigating food insecurity in conflict-affected regions. Future interventions should therefore prioritize coordinated economic and food system recovery strategies to address both immediate needs and longer-term vulnerabilities.

Conclusions: The ongoing conflict in Sudan has profoundly compromised household food access, dietary adequacy, and economic stability. Rising food prices and livelihood vulnerability significantly intensify the impact. Urgent multisectoral interventions focusing on market stabilization, livelihood restoration, and nutrition-sensitive humanitarian responses are essential to mitigate the escalating risk of food insecurity and malnutrition.

Abbreviations: χ^2: Chi-square test; p: p-value; SPSS: Statistical Package for the Social Sciences; n: number; %, percentage; ≥: greater than or equal to; ≤: less than or equal to, and <: less than.

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Authors' contributions: R. A. M. Adam, R. A. A. M. Mohamed, and A. A. M. N. Nour designed the study. R. A. M. Adam, R. A. A. M. Mohamed, H. E. Ibrahim, N. M. Osman, and O. Y. M. Ali collected the data. A. A. M. N.

Nour and M. A. Foraih performed the statistical analysis and interpreted the findings. M. AE. M. Ibrahim, L. A. E. M. N. Nour, and W. A. M. Babiker contributed to data management, validation, and the literature review. M. O. Elhorry provided software support and assisted with data cleaning. S. J. Algamdi provided institutional support and project oversight. I. E. Elmahdi contributed to the refinement of methodology and field supervision. I. I. M. A. Mohammed managed project administration and resources.

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