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Incident Food Insecurity and Associated Risk Factors After Surgical Trauma

Annabelle Jones, MD, MPH,[a,b,c,1] *Anam N. Ehsan, MBBS,*[c,1] *Shivangi Saha, MCh,*[d] *Chuan-Chin Huang, DSc, MS,*[c] *Nivedha Pillai, MBBS,*[e] *Preet Hathi, MBBS,*[d] *Srinivasan Vengadassalapathy, MBBS, MD,*[e] *Keerthana Bhat, MBBS,*[f] *Praveen Ganesh, MDS,*[e] *Shashank Chauhan, MS, MCh,*[d] *Maneesh Singhal, MCh,*[d] *S. Raja Sabapathy, MS, MCh, DNB,*[f] *Seth A. Berkowitz, MD, MPH,*[g] *and Kavitha Ranganathan, MD*[a,b,c,*]

[a] *Program in Global Surgery and Social Change, Harvard Medical School, Boston, Massachusetts*
[b] *Department of Surgery, Center for Surgery and Public Health, Brigham & Women's Hospital, Boston, Massachusetts*
[c] *Brigham & Women's Hospital, Boston, Massachusetts*
[d] *All India Institute of Medical Sciences, Delhi, India*
[e] *Saveetha Medical College and Hospital Chennai, Chennai, India*
[f] *Ganga Medical Centres and Hospitals, Coimbatore, India*
[g] *University of North Carolina School of Medicine, Chapel Hill, North Carolina*

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ABSTRACT

Introduction: Food insecurity, defined as a lack of access to adequate nutrition, impacts approximately 30% of the global population. Despite clear evidence regarding the benefit of proper nutrition on clinical outcomes, the burden of incident food insecurity after surgical intervention in previously food secure patients is unknown. The goal of the study was to quantify incident food insecurity post operatively and to identify associated risk factors.

Methods: A multicenter, prospective, longitudinal study was conducted among adult surgical trauma patients at tertiary care public and private hospitals in India. The primary outcome was new food insecurity from initial admission for traumatic injury to 6 mo post operatively. Cox proportional hazards models were used to evaluate associations between clinical and sociodemographic variables and incident food insecurity.

Results: Of 774 patients enrolled, 20% were food insecure at baseline. During the follow-up period, 21% of patients who were food secure at baseline experienced new food insecurity. Incident food insecurity was associated with longer length of stay (hazard ratio (HR): 3.76, 95% confidence interval (CI): 1.62-8.74; $P = 0.002$), intensive care unit admission (HR: 1.87, 95% CI: 1.05-3.31; $P = 0.032$), receiving welfare support (HR: 2.00, 95% CI: 1.00-3.98; $P = 0.049$) and daily wage, rather than salaried, employment (HR: 2.95, 95% CI: 1.24-7.06; $P = 0.015$). Higher total household income was associated with maintaining food security (HR: 0.24,

* *Corresponding author*. Brigham & Women's Hospital, 75 Francis Street, Boston, MA 02115.
E-mail address: kranganathan@bwh.harvard.edu (K. Ranganathan).
[1] Equal contributing first authors.
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95% CI: 0.13-0.44; $P < 0.001$). Hospitalization-related financial toxicity was significantly associated with incident food insecurity (HR: 3.07, 95% CI: 2.09-4.50; $P < 0.001$).

Conclusions: High levels of incident food insecurity were observed among surgical trauma patients. This highlights the need for serial food insecurity assessment post discharge. In lieu of serial follow-up, risk factors associated with incident food insecurity can be used to identify high-risk patients prior to discharge to facilitate connection to food insecurity interventions such as food prescription programs, monetary support, and nutritional welfare policies.

Introduction

Over 2.3 billion people experience food insecurity worldwide.[1] Food insecurity (FI) is a condition in which individuals lack access to adequate sources of nutrition as a result of financial or other resource constraints.[1-4] FI is a major public health concern, in both high-income countries and low- and middle-income countries, with the United Nations Sustainable Development Goal 2 aiming to create a world free of hunger by 2030.[5] FI is intricately linked with poverty, conflict, climate, and development.[1,6] Undernourishment and hunger increase the risk of illness and impair productivity. This creates poor individual health, increases inequities, and prevents economic growth.[1,5] Patients who experience trauma (i.e., traumatic injuries) represent a subset of surgical patients acutely at high risk for FI. Consequences of trauma, including disability, medical debt, and worse mental health, can greatly impact ability to obtain, utilize, and afford proper nutrition.[7-9] Previous cross-sectional studies demonstrated trauma patients having 1.8 times the odds of experiencing FI after discharge compared to an uninjured cohort.[7,10]

FI uniquely affects outcomes for surgical patients post operatively. It is well established that malnutrition leads to poor wound healing, prolongs inpatient length of stay (LOS), and increases morbidity and mortality in the perioperative period.[11-17] However, most studies examining FI in surgical cohorts focus on preexisting FI during admission and subsequent outcomes.[18] Little attention is given to surgical care as an inciting incident for the development of new FI post operatively. Surgical trauma care represents a crucial time point for the possible development of new food insecurity, offering an opportunity to identify at-risk patients and implement preventive measures.

Patients who are food insecure prior to traumatic injury are more likely to be identified and gain access to support programs, including nutritional welfare and other forms of assistance. Those who are food secure at the time of surgical trauma will be considered as low risk for FI and will be unlikely to be referred to nutrition programs or connected to essential resources. This places them at higher risk of poor clinical outcomes upon incident FI after discharge. This is even more pronounced due to limited serial follow-up in trauma patient cohorts as a result of financial, disability, and logistical considerations, leaving incident FI undetected.[8,16,19-22] Establishing incident FI post discharge is imperative to connecting these patients with adequate supportive infrastructure. The limited follow-up nature of trauma care may necessitate identification of patients at high-risk of incident FI at the time of surgery, to facilitate proactive connection to resources and support programs.

The goal of this study is to quantify incident FI post operatively and identify risk factors for incident FI in surgical trauma populations. This represents the first prospective longitudinal cohort study of incident FI after surgical care. The findings of this study are important to inform hospital-based identification of high-risk patients and consequent linkage prior to discharge to context-specific, community-based interventions designed to prevent FI. Given the evidence-based benefits of proper nutrition on clinical outcomes, this is likely to improve clinical outcomes and quality of life for surgical patients.

Methods

Study design and setting

We conducted a prospective, multicenter, longitudinal cohort study to evaluate incident FI after surgical trauma in three tertiary care public and private hospitals in India (Appendix 1). Data were collected from October 2021 through June 2023. The research team was led by a research manager who trained and supervised teams at all three centers. Each center had a clinical supervisor responsible for identifying patients and accurately deducing clinical information. Data collection teams composed of both clinical and nonclinical individuals—ranging from social workers to physicians—worked alongside the clinical supervisors to gather data.

Patients over the age of 18 y who underwent inpatient operative intervention for traumatic injury were eligible for inclusion. Consecutive sampling was used to recruit consenting patients from the trauma, burns, and plastic and reconstructive surgery departments. Patients who did not consent were excluded; reasons for nonconsent included privacy concerns, reluctance to disclose financial information, inability to follow-up due to lack of functional contact, unwillingness to attend follow-up visits, and anxiety about their condition. Patients were surveyed on admission to capture food security status prior to injury (i.e., baseline), and throughout the follow-up period to capture post hospitalization food security. The follow-up period was defined as 1-mo post operatively, 3-mo post operatively, and 6-mo post operatively. Data were obtained through a combination of medical records and direct patient reports by trained investigators.

The initial cohort consisted of all eligible patients who had completed the food security questionnaire on admission. To evaluate incident food insecurity, the cohort was restricted to patients who were food secure on admission and had one or more follow-up visits.

Measurement of primary outcome

The primary outcome of this study was the development of incident FI during the follow-up period. FI was assessed with survey questions adapted from the validated U.S. Department of Agriculture's Adult Food Security Survey Module (Appendix 2).[23] Incident FI was defined as a reporting food insecurity during the follow-up period, among the cohort who were food secure on admission.

Demographic variables

Patient demographic factors collected at baseline included age, gender, marital status, presence and number of children, number of people in the household, highest level of education achieved, employment status, status of current receipt of welfare, and health insurance status. Clinical covariates included LOS, injury severity score (ISS), injury cause, post-operative complications, need for intensive care unit (ICU) admission, and LOS of ICU admission. Financial covariates measured at baseline included total household income and expenditure.

Financial toxicity

Catastrophic health expenditure (CHE) was utilized as an indicator of hospital-related financial toxicity on discharge. CHE was calculated through summing direct medical costs and direct nonmedical costs and presenting this as a ratio to annual household income. A ratio of greater than 10% was defined as CHE.[24] CHE was considered a summative indicator of clinical and financial demographic covariates, therefore only univariate analysis was conducted to evaluate the association with the study outcome, and it was not considered for inclusion in the multivariate model.[24-26]

Statistical methods

Descriptive statistics were performed using Student's *t*-tests for continuous variables, and Chi-squared and Fisher's exact tests for categorical variables. We used univariate Cox proportional-hazards models to evaluate associations between covariates and the incidence of food insecurity. A multivariate Cox proportional hazards model was utilized to further investigate the relationship between LOS and incident food insecurity. Covariates for the multivariate model were selected through a priori background knowledge. These included gender, number of people in the household, education status, employment status, total annual household income, welfare status, ISS, and ICU admission. Complete data were used for multivariate analyses. The statistical analysis was conducted with the use of R (R Core Team, 2023), with utilization of the survival package for survival analysis.

Ethical approval

This study was approved by the Institutional Review Board and Ethics Committees of Harvard Medical School (IRB Protocol Number 2021P000750), and all study sites. Informed consent was obtained from all participants.

Results

Study population

Initial enrollment totaled 774 patients. Of these, 619 (80.0%) were food secure over the past 12 mo, while 155 (20.0%) were food insecure. Cohort size at follow-up was 699 patients at 1-mo, 637 patients at 3-mo, and 519 patients at 6-mo, with patient retention rates of 90%, 82%, and 67%, respectively.

Our analytic cohort included 561 patients who were food secure at baseline and had one or more follow-up visits. Demographic, clinical, and financial characteristics of this cohort are summarized in Table 1. Of these individuals, 442 (78.8%) remained food secure during the follow-up period, and 119 (21.2%) reported food insecurity at either 1-mo, 3-mo, or 6-mo post operatively. More than half of the patients that developed food insecurity experienced CHE (60.0%, $n = 66$), whereas 29% of patients who remained food secure experienced CHE ($n = 126$, $P < 0.001$) (Table 1).

Characteristics associated with incident food security during follow-up

Patient demographic characteristics associated on univariate analysis with an increased rate of incident food insecurity included having one or more children (hazard ration [HR]: 1.50 [95% confidence interval [CI]: 1.04-2.15]; $P = 0.029$), having 4-5 people in the household, as compared to 0-3 people (HR: 2.13 [95% CI: 1.35-3.37]; $P = 0.001$), being employed with daily wages, as compared to full or part-time (salaried) employment (HR: 5.12 [95% CI: 2.47-10.63]; $P < 0.001$), and receiving welfare support (HR: 5.66 [95% CI: 3.63-8.83]; $P < 0.001$). Demographic covariates associated with a decreased rate of incident food insecurity included being female (HR: 0.56 [95% CI: 0.32-0.97]; $P = 0.040$), being educated to 9th-12th standard or having university/graduate school education (HR: 0.35 [95% CI: 0.18-0.68]; $P = 0.002$; HR: 0.33 [95% CI: 0.17-0.65]; $P = 0.001$, respectively), and being in the middle or highest tertile of total annual household income (HR: 0.35 [95% CI: 0.23-0.53]; $P < 0.001$; HR: 0.17 [95% CI: 0.10-0.28]; $P < 0.001$, respectively).

Clinical characteristics associated on univariate analysis with an increased rate of incident food insecurity included increased LOS (HR: 4.64 [95% CI: 2.79-7.71]; $P < 0.001$), a moderate ISS of 25-49 (HR: 2.30 [95% CI: 1.51-3.51]; $P < 0.001$), a severe ISS of 50-75 (HR: 9.91 [95% CI: 4.51-21.79]; $P < 0.001$), injury secondary to burn (HR: 2.64 [95% CI: 1.52-4.60]; $P < 0.001$), postoperative complications during the initial hospitalization (HR: 5.49 [95% CI: 3.58-8.42]; $P < 0.001$), admission to the ICU (HR: 4.59 [95% CI: 3.14-6.69]; $P < 0.001$), and longer ICU LOS (>5 ds, HR: 3.49 [95% CI: 1.64-7.42], $P = 0.001$).

Table 1 – Demographic, clinical, and financial characteristics of baseline food secure respondents with and without incident food insecurity in the follow-up period*.

	Food secure through follow-up period	Food insecure during follow-up period
	N = 442 (78.8%)	N = 119 (21.2%)
Age (years), median (IQR)	32 (24-45)	30 (23-47)
Gender		
Male	352 (79.6%)	104 (88.1%)
Female	90 (20.4%)	14 (11.9%)
Marital status		
Single	188 (42.5%)	49 (41.2%)
Married	254 (57.5%)	70 (58.8%)
Children		
None	245 (55.4%)	53 (44.5%)
1+	197 (44.6%)	66 (55.5%)
Number of people in household		
0-3	189 (42.9%)	27 (22.7%)
4-5	181 (41.0%)	58 (48.7%)
6+	71 (16.1%)	34 (28.6%)
Highest level of education achieved		
None	16 (3.6%)	11 (9.2%)
1st to 8th standard	39 (8.8%)	22 (18.5%)
9th to 12th standard	217 (49.1%)	49 (41.2%)
University/Graduate school	170 (38.5%)	37 (31.1%)
Employment status		
Full or part time employment	268 (60.6%)	82 (68.9%)
Daily wages	4 (0.9%)	8 (6.7%)
Unemployed	152 (34.4%)	27 (22.7%)
Retired	18 (4.1%)	2 (1.7%)
Total annual household income (USD)		
<318	64 (14.6%)	54 (45.7%)
318-573	178 (40.5%)	42 (35.6%)
>573	197 (44.9%)	22 (18.6%)
Welfare status		
No	427 (97.3%)	94 (79.0%)
Yes	12 (2.7%)	25 (21.0%)
Health insurance status		
No	354 (80.1%)	101 (84.9%)
Yes	88 (19.9%)	18 (15.1%)
Length of stay		
1-5	308 (69.8%)	25 (21.4%)
6-10	85 (19.3%)	37 (31.6%)
11-20	29 (6.6%)	25 (21.4%)
> 20	19 (4.3%)	30 (25.6%)
Injury severity score		
1-24	349 (80.6%)	57 (57.6%)
25-49	82 (18.9%)	35 (35.4%)
50-75	2 (0.5%)	7 (7.1%)
Injury cause		
Traffic accident	265 (60.4%)	57 (50.9%)
Burn	27 (6.2%)	16 (14.3%)
Other	147 (33.5%)	39 (34.8%)

(*continued*)

Table 1 – (continued)

	Food secure through follow-up period	Food insecure during follow-up period
	N = 442 (78.8%)	N = 119 (21.2%)
Postoperative complications		
No	426 (96.6%)	89 (76.1%)
Yes	15 (3.4%)	28 (23.9%)
ICU admission		
No	403 (92.0%)	76 (64.4%)
Yes	35 (8.0%)	42 (35.6%)
Length of stay, ICU (days)		
0-2	24 (68.6%)	12 (28.6%)
3-5	7 (20.0%)	14 (33.3%)
>5	4 (11.4%)	16 (38.1%)
Catastrophic expenditure (CE)		
No	307 (70.9%)	44 (40.0%)
Yes	126 (29.1%)	66 (60.0%)

[*] Not all variables add up to the listed total due to missing data.

CHE was associated with a hazard ratio of 3.07 (95% CI: 2.09-4.50; $P < 0.001$) for incident food insecurity during the follow-up period (Table 2).

Longer LOS remained significantly associated with incident food insecurity after adjusting for gender, number of people in the household, education status, employment status, total annual household income, welfare status, ISS, and ICU admission (HR: 3.76 [95% CI: 1.62-8.74]; $P = 0.002$). Additional characteristics that retained significance on the multivariate model included admission to the ICU (HR: 1.87 [95% CI: 1.05-3.31]; $P = 0.032$), receiving welfare support (HR: 2.00 [95% CI: 1.00-3.98]; $P = 0.049$), and daily wage employment (HR: 2.95 [95% CI: 1.24-7.06]; $P = 0.015$). Higher total annual household incomes, within the middle and highest tertile, were significantly associated with a decreased rate of incident food insecurity (HR: 0.38 [95% CI: 0.23-0.63]; $P < 0.001$; HR: 0.24 [95% CI: 0.13-0.44]; $P < 0.001$, respectively). Gender, number of people in household, education status, ISS, and postoperative complications were not significantly associated with incident food insecurity in the multivariate model (Table 3).

Discussion

Over 20% of surgical trauma patients experienced new food insecurity within 6 mos of surgery. To our knowledge, this study is the first to characterize incident FI after surgical intervention. Longer hospital stays, lower income, daily wage employees, receiving welfare support, and ICU admission were associated with a higher likelihood of developing FI. Notably, surgery-related catastrophic health expenditure was associated with triple the rate of incident FI.

Our study emphasizes the importance of both baseline and serial screening for FI among surgical trauma patients. Successful screening programs have shown improved FI outcomes.[27,28] Kaiser Permanente Colorado, in the United States, implemented a screening and referral program, resulting in increased identification of food insecure patients and improved access to hunger relief organization resources, from 5% previously to 75% after program piloting.[28] At the University of Michigan over 80% of patients exhibited support for preoperative screening, with 32% of previously food insecure patients reporting improved outcomes.[27] Screening can be conducted in clinical settings using instruments such as the validated Hunger Vital Sign 2-item screening tool—a short, highly sensitive, and specific tool utilized in multiple contexts.[29-31] However, existing approaches focus on baseline patient screening upon primary or preoperative encounters with health care settings. Our data demonstrated that incident postoperative FI rates among previously food secure patients were equivalent to baseline FI rates. Serial screening may help identify patients who become food insecure after surgery and connect them with appropriate resources in real-time. These patients would not be captured with baseline screening alone. Challenges such as time, training, and personnel availability may hinder widespread implementation of screening.[32,33] In such cases, patients at high-risk of new FI must be identified at the time of discharge and proactive mechanisms developed for preemptive linkage to interventions, to prevent incident FI and improve clinical outcomes post operatively.

Risk factors for incident FI in our study aligned with existing risk factors for FI globally. The Food and Agriculture Organization of the United Nations details in its 2022 report that populations at risk of increased income inequality and poverty unsurprisingly face greater difficulty in accessing food. This includes low socioeconomic status and low-skilled workers, congruent to our study findings.[1] Limited coverage and social protection for obtaining health-care services also contributes to the inequality resulting in difficulties in accessing food. Previous literature has focused on the impact of existing FI on health-care costs, suggesting that reducing FI through policy interventions can offset health-care expenses.[34] In our study, we assessed CHE as an indicator of

Table 2 – Univariate, Cox proportional hazards models for development of food insecurity in a previously food-secure trauma population.

	Hazard ratio (95% CI)	P-value
Age (years)		
18-20	Reference	
21-40	0.72 (0.41-1.24)	0.237
41-60	0.82 (0.45-1.50)	0.524
61-85	0.79 (0.35-1.80)	0.581
Gender		
Male	Reference	
Female	0.56 (0.32-0.97)	0.040
Marital status		
Single	Reference	
Married	1.05 (0.73-1.51)	0.798
Children		
None	Reference	
1+	1.50 (1.04-2.15)	0.029
Number of people in household		
0-3	Reference	
4-5	2.13 (1.35-3.37)	0.001
6+	2.98 (1.80-4.93)	<0.001
Highest level of education achieved		
None	Reference	
1st to 8th standard	0.78 (0.38-1.61)	0.502
9th to 12th standard	0.35 (0.18-0.68)	0.002
University/Graduate school	0.33 (0.17-0.65)	0.001
Employment status		
Full or part time employment	Reference	
Daily wages	5.12 (2.47-10.63)	<0.001
Unemployed	0.62 (0.40-0.95)	0.030
Retired	0.37 (0.09-1.51)	0.165
Total annual household income (USD)		
<318	Reference	
318-573	0.35 (0.23-0.53)	<0.001
>573	0.17 (0.10-0.28)	<0.001
Welfare status		
No	Reference	
Yes	5.66 (3.63-8.83)	<0.001
Health insurance status		
No	Reference	
Yes	0.71 (0.43-1.18)	0.186
Length of stay		
1-5	Reference	
6-10	4.64 (2.79-7.71)	<0.001
11-20	8.17 (4.69-14.24)	<0.001
>20	12.77 (7.49-21.80)	<0.001
Injury severity score		
1-24	Reference	
25-49	2.30 (1.51-3.51)	<0.001
50-75	9.91 (4.51-21.79)	<0.001
Injury cause		
Traffic accident	Reference	
Burn	2.64 (1.52-4.60)	<0.001
Other	1.21 (0.81-1.83)	0.350
Postoperative complications		
No	Reference	
Yes	5.49 (3.58-8.42)	<0.001
ICU admission		
No	Reference	
Yes	4.59 (3.14-6.69)	<0.001
Length of stay, ICU (days)		
0-2	Reference	
3-5	2.21 (1.02-4.78)	0.045
>5	3.49 (1.64-7.42)	0.001
Catastrophic expenditure (CE)		
No	Reference	
Yes	3.07 (2.09-4.50)	<0.001

financial toxicity associated with food insecurity, which offers a unique approach not extensively explored in the literature. It is plausible that the acute economic impact of financial toxicity after surgical care results in FI. Context-specific risk identification and predictive modeling is necessary to identify surgical trauma patients in need of interventional assistance in various settings. Evidence-based interventions are subsequently required to reduce incident FI and support high-risk patients.

Connecting individuals identified at time of hospitalization with FI or at high risk of new FI to community-based interventions is crucial, especially for trauma patients who often receive limited long-term follow-up in health care.[22] Linking them to available community resources at the time of trauma can help address their nutritional needs over the long-term, even with scarce subsequent encounters with the health-care system. One feasible example of such interventions is food prescription programs. These are a less resource intensive, generalizable intervention which have shown effectiveness in improving affordability, accessibility, and consumption of healthy foods, particularly in primary care settings.[3,35-43] Their impact on trauma patients remains understudied. Community-based food program partners may serve as valuable avenues to explore referral of patients and development of food prescription programs tailored to surgical trauma.

Adequately addressing FI among trauma patients also necessitates policy-level interventions. Expanding health

Table 3 – Multivariate, Cox proportional hazards model for development of food insecurity in a previously food-secure trauma population.

	Hazard ratio (95% CI)	P-value
Length of stay		
1-5	Reference	
6-10	2.67 (1.52-4.70)	0.001
11-20	3.58 (1.78-7.20)	<0.001
> 20	3.76 (1.62-8.74)	0.002
Gender		
Male	Reference	
Female	0.54 (0.26-1.13)	0.100
Number of people in household		
0-3	Reference	
4-5	1.50 (0.88-2.57)	0.138
6+	1.63 (0.86-3.09)	0.136
Highest level of education achieved		
None	Reference	
1st to 8th standard	1.18 (0.52-2.70)	0.689
9th to 12th standard	0.63 (0.29-1.39)	0.252
University/Graduate school	0.70 (0.31-1.59)	0.389
Employment status		
Full or part time employment	Reference	
Daily wages	2.95 (1.24-7.06)	0.015
Unemployed	0.85 (0.47-1.53)	0.586
Retired	0.59 (0.14-2.54)	0.480
Total annual household income (USD)		
<318	Reference	
318-573	0.38 (0.23-0.63)	<0.001
>573	0.24 (0.13-0.44)	<0.001
Welfare status		
No	Reference	
Yes	2.00 (1.00-3.98)	0.049
Injury severity score		
1-24	Reference	
25-49	1.47 (0.90-2.38)	0.123
50-75	1.01 (0.32-3.24)	0.984
Postoperative complications		
No	Reference	
Yes	1.31 (0.60-2.89)	0.500
ICU admission		
No	Reference	
Yes	1.87 (1.05-3.31)	0.032

care coverage and adjusting eligibility criteria for nutritional and welfare support during the perioperative period can lead to improved clinical outcomes and cost savings for the health-care system.[11-14,39,44-46] For instance, enrollment in programs like the US-based Supplemental Nutrition Assistance Program has shown a reduction of $1400 USD in annual health-care expenditures.[47] However, governmental nutritional support often lacks flexibility during acute individual economic crises, underscoring the importance of adaptable policies in such circumstances. Adapting governmental policies to health insults, as seen with Supplemental Nutrition Assistance Program during the COVID-19 pandemic, can effectively prevent FI.[48] Expanding insurance coverage has effectively reduced FI, indicating the positive impact of health insurance on FI levels.[49] This finding challenges the conventional approach to policy interventions and suggests that addressing patient-level health-care costs can improve health outcomes and address health-related social needs. These implications are significant for policymaking.

Our study has important limitations. First, the study was conducted in urban, tertiary care centers in India and there was loss to follow-up. This may reduce the generalizability of our findings to the wider population. The poorest populations at highest risk of incident FI may not be able to present to these centers or have increased probability of being lost to follow-up. However, given this, it is likely that our study underreported the true burden of FI indicating an even greater burden in surgical trauma cohorts. Our cohort retention rate was approximately 70% for 6 mo postoperatively. Furthermore, we purposely selected high-quality, high-volume tertiary care centers that encompassed patients from diverse sociodemographic backgrounds to maximize generalizability. Second, the data on food insecurity relied on a single, validated, screening question, which may reduce sensitivity or lead to misclassification. To minimize this risk, we employed trained personnel and utilized simple survey questions with limited response options.

Context-specific, multitiered interventions play a critical role in proactively identifying and mitigating the risk of incident or worsening food insecurity among vulnerable patients. Implementing preventive measures through the described interventions could directly lead to improved patient outcomes in surgical trauma cohorts.

Conclusions

Surgical trauma patients are at significant risk of experiencing incident food insecurity after discharge. Development of post discharge FI was associated with longer length of hospital stay, low income, daily wage employment, receiving welfare support, and admission to the ICU. Hospital associated financial toxicity was associated with increased new FI. Serial screening within the health-care system for FI, linkage to food programs at the community level, and improved access to welfare and health care coverage perioperatively at the policy level are recommended initial steps to help mitigate incident FI after surgical trauma care.

Supplementary Materials

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jss.2025.02.008.

CRediT authorship contribution statement

Annabelle Jones: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Anam N. Ehsan:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Funding acquisition, Data curation, Conceptualization. **Shivangi Saha:** Writing – review & editing, Resources, Investigation. **Chuan-Chin Huang:** Writing – review & editing, Visualization, Software, Methodology, Formal analysis. **Nivedha Pillai:** Writing – review & editing, Resources, Investigation. **Preet Hathi:** Writing – review & editing, Resources, Investigation. **Srinivasan Vengadassalapathy:** Writing – review & editing, Resources, Investigation. **Keerthana Bhat:** Writing – review & editing, Resources, Investigation. **Praveen Ganesh:** Writing – review & editing, Resources, Investigation. **Shashank Chauhan:** Writing – review & editing, Resources, Investigation. **Maneesh Singhal:** Writing – review & editing, Resources, Investigation. **S. Raja Sabapathy:** Writing – review & editing, Resources, Investigation. **Seth A. Berkowitz:** Writing – review & editing, Validation, Methodology. **Kavitha Ranganathan:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Funding acquisition, Conceptualization.

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Disclosure

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