



Food and nutrition security in persons with disabilities. A scoping review

Robyn Moore^{a,*}, Shakila Dada^a, Mohammad Naushad Emmambux^b, Alecia Samuels^a

^a Centre for Augmentative and Alternative Communication, University of Pretoria, Hatfield, Pretoria, 0028, South Africa

^b Department of Consumer and Food Sciences, Faculty of Natural and Agricultural Sciences, University of Pretoria, South Africa

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ABSTRACT

Food and nutrition security (FNS) is achieved when food that is adequate in quantity, quality, safety and socio-cultural acceptability is available, accessible and utilized satisfactorily by individuals to promote a healthy life. Persons with disabilities (PWD) are particularly vulnerable to food and nutrition insecurity, yet there seems to be a paucity of relevant research and policy. This scoping review identified 76 articles that met the criteria and describes the extent of research addressing FNS in PWD and categorizes studies according to the levels of social organization (individual to global). Literature is inadequate particularly regarding higher levels of social organization, national and global strategies for assessment and intervention, and indicators of FNS for people living with disabilities. More studies should explore intervention strategies that address FNS at community level.

1. Introduction

The concept and definition of food security was first introduced in the early 1940s (Pangaribowo et al., 2013). It was only after 1980 that it developed from a food supply perspective to one that considered food insecurity as a result of food scarcity and institutional failures that lead to suboptimal food distribution (Pangaribowo et al., 2013). The latter perspective acknowledges that food may be physically existent, but inaccessible to those who are in need (Gross et al., 2000).

The Food and Agriculture Organization of the United Nations (FAO) defines nutrition security as follows:

A condition when all people at all times consume food of sufficient quantity and quality in terms of variety, diversity, nutrient content and safety to meet their dietary needs and food preferences for an active and healthy life, coupled with a sanitary environment, adequate health and care (Committee on World Food Security, 2012 as cited in Pangaribowo et al., 2013, p. 5).

Food insecurity is a significant determinant of many forms of malnutrition (FAO, 2019). In upper-middle and high-income countries, living in a food-insecure household is a predictor of obesity in children and adults, while in low-income countries, severe food insecurity and undernutrition are more prevalent, as a result of income and wealth inequalities (FAO, 2019).

While food security focuses on the physical substances that people consume to maintain life and growth, nutrition adds aspects of health services, healthy environments and caring practices (Pangaribowo et al.,

2013).

Food and nutrition security (FNS), a term coined by Gross et al., in 1998, is used to combine and highlight the relationship between the concepts of food security and nutrition security (Pangaribowo et al., 2013). FNS is achieved when food that is adequate in quantity, quality, safety and socio-cultural acceptability, is available and accessible for, as well as utilized satisfactorily by all individuals, at all times, to live a happy and healthy life (Gross et al., 2000).

The definition of FNS encompasses four main determinants: availability, accessibility, use and utilization, and stability (Weingartner, 2004). A further component is the temporal determinant, stability, which relates to each of the physical determinants (Weingartner, 2004). The inclusion of use and utilization as a determinant underscore the fact that nutrition security is more than food security.

In this context, availability refers to sufficient quantities of food being available on a consistent basis (El Bilali et al., 2018), at the household, regional or national level (Weingartner, 2004).

Accessibility implies that households and individuals within households have sufficient resources to obtain appropriate food for a nutritious diet (Gross et al., 2000). To a large extent, food access is influenced by food prices and household resources (Pieters et al., 2013). Every household has limited resources such as assets, labor, human capital and natural resources at its disposal (Pieters et al., 2013). Dorhmann and Thorat (2007) highlight socio-political factors that impact accessibility too, such as social discrimination and gender inequality.

Use of food is a socio-economic aspect of household food security

* Corresponding author.

E-mail address: robynleighmoore@gmail.com (R. Moore).

(Weingartner, 2004). Assuming that sufficient and nutritious food is available and accessible, households must decide *what* food will be purchased, prepared and consumed, and *how* food will be distributed within the household (Weingartner, 2004).

Utilization refers to the ability of the human body to ingest and metabolize food (Gross et al., 2000). It is the result of feeding practices, food preparation, dietary diversity and fair distribution of food within households (El Bilali et al., 2018).

Stability refers to the temporal element of FNS and affects all three physical elements (Gross et al., 2000). Stability incorporates *vulnerability* and *resilience*, where vulnerability refers to the likelihood of experiencing future welfare loss, and resilience refers to the ability to recover from such a welfare loss (Pieters et al., 2013).

The FIVIMS (Food Insecurity and Vulnerability Information and Mapping Systems) (Weingartner, 2004), a document presented by the FAO, identified persons with disabilities and the unemployed, homeless and orphaned as vulnerable and at high risk of food and nutrition insecurity. Persons with disabilities are particularly vulnerable to chronic food and nutrition insecurity as challenges of requesting food, feeding or swallowing (to name a few) could further aggravate their situation. This is especially alarming as the WHO (2011) estimates that more than 1 billion people live with some form of disability (i.e. about 15% of the world population), with the rates of disability increasing. The FAO estimates that 2 billion people worldwide experience moderate to severe levels of food insecurity (FAO, 2019).

Although the fields of food and nutrition insecurity and disability are interrelated, research on the two constructs has mostly been separate (Groce et al., 2014) owing to a poor understanding of their intersectionality (Quarmby and Pillay, 2018). Malnutrition and disability can both limit life opportunities severely (Groce et al., 2013). Both involve key human rights, are more prevalent in poor countries and feature within the global health agenda (Groce et al., 2013). Heflin et al. (2019) suggest an intrinsic link between food insecurity and disability, stating that food insecurity is more prevalent in households with disabilities, which constitute a large share of the overall food insecure population. According to Heflin et al. (2019), disabling health conditions interfere with a household's ability to provide adequate food and nutrition.

Schwartz et al. (2019), in their review on disability and food access and insecurity highlighted a total of 106 papers that met their inclusion criteria. The findings highlight that a number of access barriers were experienced by persons with disabilities. Some of these barriers to access include additional living expenses due to medical and disability related equipment (She and Livermore, 2007), use of public transport which limits purchasing options (Shannon, 2016) and difficulty physically shopping and preparing food which leads to purchasing more processed meals which are of a lower nutritional value and higher in cost (Bilyk et al., 2009). Schwartz et al. (2019) acknowledge that their review mostly included studies from high-income countries, and it can be assumed that these accessibility challenges are exacerbated in low- and middle-income countries. Whilst the Schwartz et al. (2019) study is an important review focusing on food security in persons with disabilities, it does not necessarily include the focus on Food and Nutrition security. Furthermore, the search terms and databases were limited. The authors believe there is great value in building on the Schwartz et al. (2019) review by addressing each of the determinants of FNS, as opposed to just accessibility as well as enhancing the search strategies and databases. Such a review would serve to not only highlight literature that may have been omitted by Schwartz et al. (2019) but could also include literature from lower and middle income countries.

Quarmby and Pillay (2018) argue that physical, social and financial barriers still do not encompass all the access issues that people with disabilities encounter daily. They should include behavioral or cognitive access such as self-feeding skills and physiologic access to food and liquid through swallowing, as additional issues that people living with disabilities could encounter (Quarmby and Pillay, 2018). Arvedson (2008) explains that the ability to feed is dependent on a number of

different skills, capabilities and functions, which may be impaired in various ways in different types of disabilities. Quarmby and Pillay (2018) therefore argue that food access concerns like feeding and swallowing and reduced mobility or communication disorders resulting in a reduced ability to request food are significant when considering disability and FNS.

The determinants of FNS, i.e., availability, access, use and utilization, and stability of food affect all levels of social and administrative organizations – from the individual and household (micro level), to the community (sub-district, district and province) or meso level, and the nation and the global (macro) level (Weingartner, 2004).

Food and nutrition insecurity at different socio-organizational levels is caused by different factors and requires specific solutions at each level (Weingartner, 2004). Various instruments to assess FNS, indicators of FNS and intervention instruments of FNS exist at each of the social levels (Weingartner, 2004). A broad range of tools is used to measure FNS (Fielden et al., 2014) and instruments and processes selected for assessment of FNS are specific (though interlinked) at each level (Weingartner, 2004). For example, measures to assess access to food at the macro level differ from those used at micro and meso levels (Gross et al., 2000). A Vulnerability Analysis and Mapping (VAM) (Gross et al., 2000) instrument measures accessibility of food at the macro level, while food focus group discussions and intra-household food frequency questionnaires are more appropriate to measure access at the meso and micro levels respectively. Gross et al. (2000) suggest that FNS is a complex system that requires a holistic program approach, while Quarmby and Pillay (2018) argue that this system is even more complex when applied to persons with disabilities.

Since literature addressing food and nutrition security of people with disabilities is scarce, this review helps to determine the social levels covered in existing literature by addressing the following question: *What is the focus, extent and nature of literature on food and nutrition security related to people living with disabilities?*

More specifically, the review had the following aims:

- Providing an overview of the general characteristics of available studies, i.e. the number, location and setting of studies, the types of disabilities, the study participants, and the group focused on (e.g. persons with disability, caregivers, healthcare workers).
- Mapping and categorizing the literature according to the various determinants of FNS addressed, namely availability, accessibility, use and utilization, and stability of food.
- Describing the assessment, indicators and interventions of FNS relating specifically to persons with disabilities and exploring where they map on the levels (micro, meso and macro) of social organization as proposed by Gross et al. (2000).
- Highlighting the gaps identified in this review relating to the determinants of FNS and persons with disabilities.

2. Methods

Our scoping review followed five of the six steps detailed by Arksey and O'Malley (2005) as they allowed us to include a range of study designs and methods and collect information on a broad scope (Sucharew and Macaluso, 2019). The steps included identifying the research question and relevant studies, selecting studies, charting and collating the data, summarizing and reporting the results (Arksey & O'Malley, 2005). Our report followed the PRISMA-ScR proposed by Tricco et al. (2018). A systematic review was not deemed appropriate for our wide-ranging search, as it is more useful in answering specific questions and hypothesis testing (Tricco et al., 2016; Grant and Booth, 2009). Scoping reviews differ from systematic reviews in that they do not require a formal appraisal of the quality of evidence (Sucharew and Macaluso, 2019).

2.1. Search terms

The search terms were relevant to the review question and refined through pilot exploratory searches and consultation with a librarian. Search terms using keywords related to disability terminology and food and nutrition security terminology were used to replicate the search in each of the databases.

2.2. Data sources

The search terms were used to identify published research in the following databases: Scopus, Africa-Wide, Medline, Cumulative Index to Nursing and Allied Health Nursing (CINAHL) and Ebscohost. A multi-faceted search strategy was used which included data base searches. Further searches included hand searches of Disability and Health Journal and Global Food Security journals and an ancestral search of studies that met the inclusion criteria. Search limiters were used to include only articles published in English between September 2015 and June 2020 (see Table 1).

2.3. Eligibility criteria

Studies were selected using a screening relevance tool and screening was completed independently by two authors using Covidence, a web-based platform software application tool that enables efficient production of systematic reviews (Veritas Health Innovation, n.d.). A Title and Abstract Screening Relevance Tool was developed to screen study titles and abstracts, and to determine their eligibility for inclusion or exclusion based on the criteria in Table 2.

Based on the eligibility criteria, a ‘yes’, ‘no’ or ‘maybe’ response was selected at title and abstract level in Covidence. If both authors selected ‘no’, the study was excluded. If a reviewer selected ‘yes’ or ‘maybe’, the study was included at full text. At full text, a reason was selected from a list of drop-down options in Covidence to substantiate the exclusion of a study. The two authors completed this process blindly and independently. Discrepancies were discussed thereafter until consensus was reached.

Table 1
Search terms by database.

Scopus	ALL (disab* OR "special needs" OR "develop* delay*") AND ALL ("food insecur*" OR "food secur*" OR "nutr* secur*" OR "nutrition* insecur*" OR "nutrition* deficien*" OR malnutrition OR malnourish*)
Africa-Wide	Boolean/Phrase: (disab* OR "special needs" OR "develop* delay*") AND ("food insecur*" OR "food secur*" OR "nutr* secur*" OR "nutrition* insecur*" OR "nutrition* risk*" OR "nutrition* deficien*" OR malnutrition OR malnourish*)
Ebscohost (Deselect Africa-Wide, CINAHL, Medline)	Boolean/Phrase: (disab* OR "special needs" OR "develop* delay*") AND ("food insecur*" OR "food secur*" OR "nutr* secur*" OR "nutrition* insecur*" OR "nutrition* risk*" OR "nutrition* deficien*" OR malnutrition OR malnourish*)
Medline	Boolean/Phrase: (disab* OR "special needs" OR "develop* delay*") AND ("food insecur*" OR "food secur*" OR "nutr* secur*" OR "nutrition* insecur*" OR "nutrition* risk*" OR "nutrition* deficien*" OR malnutrition OR malnourish*)
CINAHL	Boolean/Phrase: (disab* OR "special needs" OR "develop* delay*") AND ("food insecur*" OR "food secur*" OR "nutr* secur*" OR "nutrition* insecur*" OR "nutrition* risk*" OR "nutrition* deficien*" OR malnutrition OR malnourish*)

Table 2
Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
<p>Population People with disabilities as defined by the United Nations (2006) – any “long-term physical, mental, intellectual or sensory impairments that, in interaction with various attitudinal and environmental barriers, hinder full and effective participation in society on an equal basis with others”. Including special needs, impairment, developmental delay, developmental disability, ASD, ADHD, dysphagia, feeding difficulty, stroke.</p> <p>Concept Studies relating to food and nutrition security and its determinants (availability, accessibility, use and utilization and stability). Instruments to assess FNS such as food balance sheets; agricultural production plans; dietary recalls; household food frequency questionnaires; anthropometric measurements (weight, BMI, mid-upper arm circumference). Indicators of FNS such as food production; market and retail food prices; food price fluctuation; meal and food frequency in homes; stunting rates; wasting rates; weight for age, goiter; anemia. Intervention instruments of FNS such as small-scale irrigation projects; food gardens; school-feeding programs; nutrition supplementation programs. Food security and food insecurity; nutrition security and nutrition insecurity (stunting, wasting, underweight, low birth weight). Research published on malnutrition and nutritional deficiencies (iron, iodine, calcium, vitamin A, folate).</p> <p>Design Publication type – English only. Published in peer-reviewed academic journals. Between September 2015 and June 2020.</p>	<p>People without disabilities; people at risk of disabilities; people in poverty situations; prematurity; sarcopenia; the frail and the elderly. Functional limitations, retarded growth and epilepsy. Mood disorders. Noncommunicable diseases such as diabetes, cancer, cardiovascular and respiratory diseases. People living with HIV/AIDS and/or TB. Long-term health conditions.</p> <p>Research relating to overnutrition (overweight or obesity) or risk of overnutrition and high BMI. Non-nutritional interventions, non-nutritional pharmaceutical trials and surgical interventions like PEG.</p> <p>Publication type – Non-English publications. Published prior to September 2015. Publications not available through the University of Pretoria’s library.</p>

2.4. Data extraction

A data-charting form was developed, as proposed by Levac et al. (2010), to extract all the relevant information needed from each article to answer the research question. Google Sheets was used to enter the data. The data-charting form includes general information regarding the study such as the year of publication, study location, descriptors of the study participants and aims of the study. A descriptive analytical method was adopted, and data was extracted and captured according to the information provided in each article. Where information was reported on individuals, data was captured as such, and the same for households or communities. More specific information relating to each of the sub-questions was also included on the data-charting form, such as the aspect of the FNS definition addressed (availability, accessibility, use and utilization and/or stability of food); the indicators, measures or interventions of FNS addressed; and the levels of social organization addressed.

Data extraction was conducted by the first author independently and captured on the Google Sheets form. The second author then independently checked 50% of the data extracted and discrepancies were

discussed by the authors until consensus was established.

3. Results

The search results are illustrated in the PRISMA-ScR (Tricco et al., 2018) diagram depicted in Fig. 1.

A total of 5768 titles and abstracts were independently screened by two authors. Thereafter, three reviewers screened 174 articles for eligibility, where 98 articles were excluded for not relating to food or nutrition security (i.e. patients with long-term health conditions listed in the exclusion criteria, the wrong publication type or study design). Articles not available through the University of Pretoria library were excluded as well as articles not published in English. A total of 76 articles were then included for data extraction, the general characteristics of which are detailed in Table 3.

3.1. General characteristics of included studies

Of the 76 studies included, most originated in Japan ($n = 9$) (Kimura et al., 2017; Kishimoto et al., 2020; Nishioka et al., 2017, 2020; Sato et al., 2019; Shimizu et al., 2019; Takada et al., 2017; Tanaka et al., 2019; Yanagimoto et al., 2020), closely followed by the USA ($n = 8$)

(Barnhill et al., 2017; Evans et al., 2016; Holton et al., 2019; Keogh et al., 2020; Kushalnagar et al., 2018; Malone et al., 2016; Martinez et al., 2018; Raffee et al., 2019), and Brazil ($n = 5$) (Caramico-Favero et al., 2018; Castro et al., 2016; Castro et al., 2017; Dos Santos et al., 2018; Silva et al., 2017) (see Table 4). Spain (Barrio et al., 2020; Fuentes-Albero et al., 2019; Norte et al., 2019; Redondo Robles et al., 2019), China (Guo et al., 2019; Liu et al., 2016; Pei et al., 2016; Wang et al., 2016) and Malaysia (Ahmad et al., 2020; Sha'ari et al., 2017; Weun et al., 2019; Ying et al., 2019) each contributed four studies, while three studies each were conducted in Australia (Bell et al., 2019; Koritsas and Iacono, 2016; Spurway and Soldatic, 2016) and Iran (Aliasghari et al., 2019; Moludi et al., 2019; Shidfar et al., 2016). Two studies from each of the following countries were included: Egypt (Bebars et al., 2019; Meguid et al., 2017); Taiwan (Chang et al., 2017; Tsai et al., 2018); Mexico (García Iníguez et al., 2017; García Iníguez et al., 2018); Belgium (Huysentruyt et al., 2020; Leonard et al., 2020); India (Hariprasad et al., 2017; Malhi et al., 2017); Ghana (Donkor et al., 2019; Polack et al., 2018); and Chile (Barja and Perez, 2016; Figueroa et al., 2017). One study was included from Morocco (Hafid and Touhamiahami, 2018); Kuwait (Alkazemi et al., 2018); Thailand (Bualar, 2016); Malta (Coppini et al., 2018); Ethiopia (Endale and Tolossa, 2017); the UK (Hardy et al., 2018); Colombia (Herrera-Anaya et al., 2016); Indonesia (Jahan et al.,

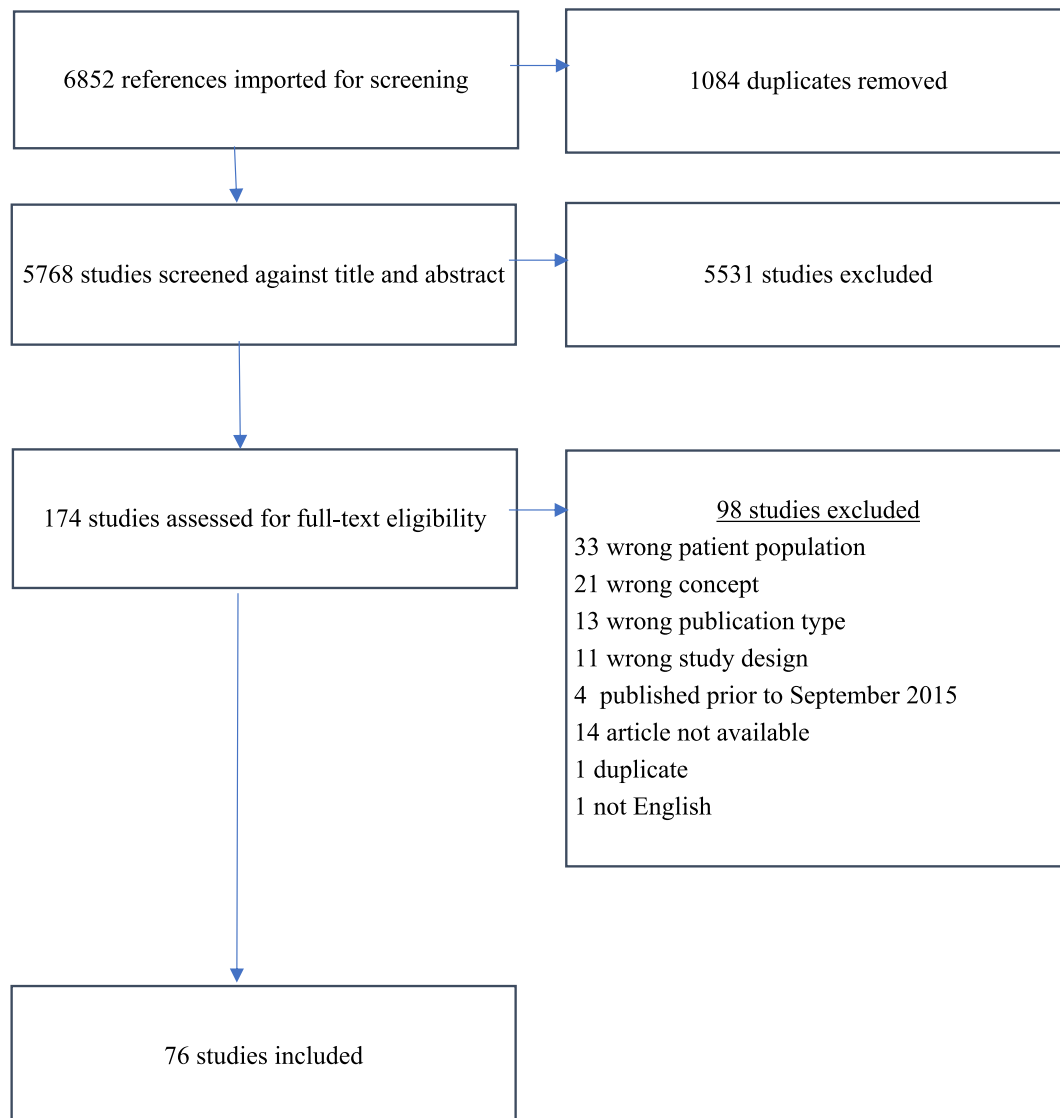


Fig. 1. PRISMA-ScR diagram (adapted from Tricco et al., 2018).

Table 3
Summary of included studies.

	Title	Authors	Year of publication	Study design	Number of participants	Type of disability included	Key findings	Aspect of definition of FNS included	Social level of FNS addressed	Instrument used to assess FNS
1	Malnutrition is common in children with cerebral palsy in Saudi Arabia – a cross-sectional clinical observational study	Almuneef et al.	2019	Cross-sectional clinical observational study	74	Cerebral palsy	41 children were malnourished (55.4%) 72% and 66% had adequate energy and protein intake respectively	Accessibility Use & utilization	Micro – Individual	Anthropometric data
2	A multicenter cross-sectional study to evaluate the clinical characteristics and nutritional status of children with cerebral palsy	Aydin et al.	2018	Cross-sectional, non-interventional multicenter single-visit study	1108	Cerebral palsy	766 (83.7%) participants had some degree of malnutrition according to WHO	Use & utilization	Micro – Individual	Anthropometric data
3	Clinical assessment underestimates fat mass and overestimates resting energy expenditure in children with neuromuscular diseases	Barja and Pérez	2016	A descriptive observational study	40	Duchenne muscular dystrophy (21); other dystrophies (7); muscular spinal atrophy (7); myopathies (3); others (2)	42.5% were undernourished 23 (57.5%) had low height/age	Accessibility Use & utilization	Micro – Individual	Anthropometric data
4	Growth status of children with autism spectrum disorder: A case-control study	Barnhill et al.	2017	Case control study	86 + 57 controls	Autism spectrum disorder	30.6% were below 5th percentile for MUAMC 5% were underweight according to their BMI	Use & utilization	Micro – Individual	Anthropometric data
5	Assessment of some micronutrients' serum levels in children with severe acute malnutrition with and without cerebral palsy – A follow-up case control study	Bebars et al.	2019	Prospective nonrandomized case control study	160 SAM (80 with CP) + 96 controls	Cerebral palsy	Malnourished children with CP have significantly lower serum levels (zinc, copper and selenium) than non-neurologically impaired malnourished children.	Use & utilization	Micro – Individual	Nutrient deficiencies
6	Oral health and nutritional status of children with cerebral palsy in northeastern peninsular Malaysia	Ahmad et al.	2020	Cross-sectional study	93	Cerebral palsy	BMI: 8.1% thinness and 46.5% severe thinness HAZ: 16.4% stunted and 81.4% severe stunted	Accessibility Use & utilization	Micro – Individual	Anthropometric data
7	The nutritional status of adult female patients with disabilities in Kuwait	Alkazemi et al.	2018	Cross-sectional descriptive survey	53	Intellectual and physical disabilities	MNA-SF1: 30 women at risk and 8 malnourished MNA-SF2: 25 at risk and 17 malnourished	Use & utilization	Micro – Individual	Anthropometric data MNA-SF1 and MNA-SF2
8	Development and validation of a screening tool for feeding/swallowing difficulties and undernutrition in children with cerebral palsy	Bell et al.	2019	Prospective, cross-sectional, observational study	89	Cerebral palsy	SGNA: 20 (22%) moderately undernourished SGNA: 6 (7%) severely undernourished	Use & utilization	Micro – Individual	Anthropometric data Subjective Global Nutrition Assessment
9	Municipality and food security promotion for disabled people: Evidence from north-eastern Thailand	Bualar	2016	Qualitative study	21	Physical disabilities	Some disabled persons want to participate in paid jobs and believe that earning money from work could secure their food access. The final decision about food is made for them by family members.	Accessibility Stability	Meso – District	
10	Food intake, nutritional status and gastrointestinal symptoms in children with cerebral palsy	Caramico-Favero et al.	2018	Cross-sectional study	40	Cerebral palsy	The protein and carbohydrate intake was above the RDA in 92.5% (37/40) and 85.0%	Use & utilization	Micro – Individual and household/family	Anthropometric data Household food intake inquiry

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Table 3 (continued)

Title	Authors	Year of publication	Study design	Number of participants	Type of disability included	Key findings	Aspect of definition of FNS included	Social level of FNS addressed	Instrument used to assess FNS
11	Caselli et al.	2017		54	Spastic quadriplegic cerebral palsy	(34/40) of the participants respectively. 72.22% of patients were classified as eutrophic for BMI 22.22% were below the 25th percentile for weight	Use & utilization	Micro – Individual	Anthropometric data
12	Castro et al.	2017		63	Autism spectrum disorder	15.8% were classified as underweight	Use & utilization	Micro – Individual	
13	Chang et al.	2017	Cross-sectional design	213	Dementia	21.6% of residents (n = 46) had a lower BMI than the 18.5 kg/m2 defined by WHO as being malnourished	Use & utilization	Micro – Individual	
14	Coppini et al.	2018	Case report	3	Autism spectrum disorder			Micro – Individual	
15	Dos Santos et al.	2018	cross-sectional, prospective and observational study	43	Alzheimer's disease	Nutritional status – Adequate 10 (31.3%) Risk of malnutrition 21 (65.6%) Malnutrition 1 (3.1%)	Use & utilization	Micro – Individual	Anthropometric data MNA
16	Endale et al.	2017	Mixed – qualitative and quantitative approaches	80	Physical, visual, speech and or hearing	87.5% were found to be chronically food insecure 5% of the participants reported being food secure	Availability Accessibility Use & utilization Stability	Meso – Province/City	Coping Strategy Index (CSI)
17	Shirley et al.	2016	Descriptive cross-sectional study	74	Fetal alcohol spectrum disorder	16% were underweight according to BMI	Use & utilization	Micro – Individual	Anthropometric data
18	Fuentes-Albero et al.	2019	Observational case-control study	48	Attention deficit hyperactivity disorder	4.2% had low weight	Accessibility Use & utilization	Micro – Individual	Anthropometric data
19	García Iníguez et al.	2018	Cross-sectional study	79	Spastic cerebral palsy		Use & utilization	Micro – Individual	Anthropometric data
20	García-Iníguez et al.	2017	Cross-sectional design	103	Cerebral palsy	Underweight by BMI: Female 19 (35.8%) Underweight by BM: Male 15 (27.3%) Stunted: Female 6 (11.3%) Stunted: Male 1 (1.8%)	Use & utilization	Micro – Individual	Anthropometric data
21	Hardy et al.	2018	Observational study	53	Moderate-to-severe learning disability	Anthropometry and bioelectrical impedance analysis of body composition were feasible to obtain in	Use & utilization	Micro – Individual	Anthropometric data

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Table 3 (continued)

Title	Authors	Year of publication	Study design	Number of participants	Type of disability included	Key findings	Aspect of definition of FNS included	Social level of FNS addressed	Instrument used to assess FNS	
22	Association between gross motor function and nutritional status in children with cerebral palsy: A cross-sectional study from Colombia	Herrera-Anaya et al.	2016	Cross-sectional study	177	Cerebral palsy	children with special needs in school settings. Reliability of measurements varied largely between children who could stand and those unable to stand unassisted. 89 (63.1%) patients had mild or moderate to severe malnutrition using weight-for-age 117 (66.4%) had mild or moderate to severe stunting 81 (46.3%) had mild or moderate/severe malnutrition using BMI-for-age	Use & utilization	Micro – Individual	Anthropometric data
23	Evaluation of dietary intake in children and college students with and without attention-deficit/hyperactivity disorder	Holton et al.	2019		44	Attention deficit hyperactivity disorder	No significant differences between those with and without ADHD for macronutrient and omega 3 fatty acid intake and overall dietary quality	Accessibility	Micro – Individual	Food records
24	Nutritional red flags in children with cerebral palsy	Huysentruyt et al.	2020	Prospective, longitudinal observational study	325	Cerebral palsy	Nutritional red flags, present in about 40% of the Flemish CP children	Use & Utilization	Micro – Individual	Anthropometric data
25	Nutritional status of children with cerebral palsy in remote Sumba Island of Indonesia: A community-based key informants study.	Jahan et al.	2019	Community-based key informant method survey	130	Cerebral palsy	78.8% (n = 63) of the children were severely underweight, 85.9% (n = 110) were severely stunted	Use & Utilization	Micro – Individual	Anthropometric data
26	Nutritional status of children with cerebral palsy—findings from prospective hospital-based surveillance in Vietnam indicate a need for action	Karim et al.	2019	Active prospective hospital-based surveillance	765	Cerebral palsy	28.9% (n = 213) were underweight 24.9% (n = 144) were wasted	Use & Utilization	Micro – Individual	Anthropometric data
27	Health, functional, psychological and nutritional status of cognitively impaired long-term care residents in Poland	Kijowska et al.	2020	Cross-sectional survey	455	Cognitive impairment	12.8% (58) were underweight	Use & Utilization	Micro – Individual	Anthropometric data
28	Combination of Low Body Mass Index and Low Serum Albumin Level leads to poor functional recovery in stroke patients	Kimura et al.	2017	Retrospective observational cohort study	259	Subacute stroke	Underweight status was present in 17.8%	Use & Utilization	Micro – Individual	Anthropometric data
29	Weight, nutrition, food choice, and physical activity in adults with intellectual disability	Koritsas and Iacono	2016		68	Intellectual disabilities	No adults were underweight 17.6% of participants achieved scores that put them in the high-risk category Participants with ID had little choice in their food	Accessibility	Micro – Individual	Australian Nutrition Screening Initiative checklist
30	Communication barrier in family linked to increased risks for food	Kushalnagar et al.	2018	Descriptive study	475	Deaf	8% 'often' experienced problems with buying food or	Accessibility	Micro – Individual	

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Table 3 (continued)

Title	Authors	Year of publication	Study design	Number of participants	Type of disability included	Key findings	Aspect of definition of FNS included	Social level of FNS addressed	Instrument used to assess FNS
insecurity among deaf people who use American Sign Language						not being able to make the food last, whereas 28% reported experiencing this 'sometimes'.			US Household Food Security Survey Module
31 Protein-energy malnutrition is frequent and precocious in children with Cri du Chat syndrome	Lefranc et al.	2016	Questionnaire-based retrospective study	36	Cri du Chat syndrome	17 children (47%) experienced protein energy malnutrition	Use & Utilization	Micro – Individual	Anthropometric data
32 Nutritional status of neurologically impaired children: Impact on comorbidity	Leonard et al.	2020	Single-center retrospective study	260	Neurological impairment	55 children had acute malnutrition (28 moderate, 25 severe, two unclassified) 47 children had chronic malnutrition (29 moderate, 18 severe)	Use & Utilization	Micro – Individual	Anthropometric data
33 Correlation between nutrition and symptoms: Nutritional survey of children with autism spectrum disorder in Chongqing, China	Liu et al.	2016	Cross-sectional study	154	Autism spectrum disorder	All Z-scores for the children with ASD, including ZHA, ZWA and ZBMA were significantly lower than those for the TD children. Higher rate of stunting/short stature, compared to those without ASD	Accessibility Use & Utilization	Micro – Individual	Anthropometric data Food records
34 Growth and nutritional risk in children with developmental delay	Malone et al.	2016	Retrospective analysis	415	Developmental disabilities	48.88% of patients were at moderate or high nutritional risk. 16.87% (n = 70) were deemed in the high nutritional risk category	Accessibility Use & Utilization	Micro – Individual and family/ household	Parent Nutrition Screening Checklist (PNSC)
35 Comprehensive nutritional and metabolic assessment in patients with spinal muscular atrophy: Opportunity for an individualized approach	Martinez et al.	2018	Prospective study	12	Spinal muscle atrophy	Low prevalence of malnutrition in cohort (19%)	Accessibility Use & Utilization	Micro – Individual	Anthropometric data Food records
36 Dietary adequacy of Egyptian children with autism spectrum disorder compared to healthy developing children	Meguid et al.	2017	Case-control study	80 +80 TD children	Autism spectrum disorder	Weight, as well as weight for height Z-score and weight for age Z-score, were significantly higher in children with autistic disorder compared to healthy controls	Accessibility Use & Utilization	Micro – Individual and family/ household	Anthropometric data Food Frequency Questionnaire
37 Anthropometric parameters of nutritional status in children with cerebral palsy	Melunovic et al.	2017		80	Cerebral palsy	38 (47.5%) of respondents were underweight	Use & Utilization	Micro – Individual	Anthropometric data
38 The effect of a practical nutrition education programme on feeding skills of caregivers of children with cerebral palsy at Muhimbili National Hospital, in Tanzania	Mlinda et al.	2018	A randomized controlled intervention study	Intervention: 63 Control: 47	Cerebral palsy	Intervention significantly improved feeding skills of caregiver in the selected indicators assessed		Micro – Family/ household	Intervention: Nutrition education
39 Comparison of dietary macro and micronutrient intake with physical activity levels among children with and without autism: A case-control study	Moludi et al.	2019	Case-control study	ASD:30 29 Controls:29	Autism spectrum disorder	Significant clinical deficiency in nutrients intake of children with autism No significant difference in BMI	Accessibility Use & Utilization	Micro – Individual and family/ household	Anthropometric data Food Frequency Questionnaire
40	Nishioka et al.	2020		420	Stroke				

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Table 3 (continued)

Title	Authors	Year of publication	Study design	Number of participants	Type of disability included	Key findings	Aspect of definition of FNS included	Social level of FNS addressed	Instrument used to assess FNS
Concurrent and predictive validity of the Mini Nutritional Assessment Short-Form and the Geriatric Nutritional Risk Index in older stroke rehabilitation patients			Retrospective observational cohort study			125 patients were malnourished (29.8%)	Use & Utilization	Micro – Individual	Anthropometric data Malnutrition Universal Screening Tool Mini Nutritional Assessment - Short Form Geriatric Nutritional Risk Index (GNRI)
41 Accuracy of non-paralytic anthropometric data for nutritional screening in older patients with stroke and hemiplegia	Nishioka et al.	2017	Cross-sectional study	488	Stroke	483 at risk for malnutrition 205 had malnutrition	Use & Utilization	Micro – Individual	Anthropometric data Mini Nutritional Assessment – Short Form
42 Nutritional status and cardiometabolic risk factors in institutionalized adults with cerebral palsy	Norte et al.	2019	Descriptive and observational analytical study	41	Cerebral palsy	BMI: Underweight 14 (34.1%) More than 80% of the population studied was malnourished or at risk of malnutrition, according to the MNA tool classification ranges	Use & Utilization	Micro – Individual	Anthropometric data Mini Nutritional Assessment – Short Form
43 Participation of physically challenged people in agricultural value chain: Implication on food sustainability in Nigeria	Ogunjumi et al.	2016	Quantitative	105	Physically challenged	Majority of the physically challenged people participated in agriculture at low level, due to the constraints ranging from discrimination, inadequate assistance and rehabilitation appropriate for agricultural workers	Accessibility	Meso – Community (District/Town)	
44 Effect of stroke on nutritional status and its relationship with dysphagia	Barrio et al.	2020	Observational, descriptive, longitudinal and prospective study	166	Stroke	Risk of malnutrition 22 (13.4%) – after three months: 28 (17.1%) Malnutrition 1 (0.6%) – after three months: 2 (1.2%)	Use & Utilization	Micro – Individual	Anthropometric data Mini Nutritional Assessment – Short Form
45 Factors associated with activities of daily living among the disabled elders with stroke	Pei et al.	2016	Cross-sectional design	152	Stroke	Risk of malnutrition 117 (77.0%)	Use & Utilization	Micro – Individual	Anthropometric data
46 Children with cerebral palsy in Ghana: Malnutrition, feeding challenges, and caregiver quality of life	Polack et al.	2018	Cross-sectional survey	76	Cerebral palsy	65% of children aged under 5 years were categorized as underweight, 54% as stunted, and 58% as wasted	Use & Utilization	Micro – Individual and family/household	Anthropometric data
47 Lessons in early identification and treatment from a case of disabling vitamin C deficiency in a child with autism spectrum disorder	Rafee et al.	2019	Single case report	1	Autism spectrum disorder	Youth with ASD are at increased risk of experiencing food selectivities that can result in a variety of costly and debilitating consequences, particularly when associated with nutritional deficiencies	Use & Utilization	Micro – Individual	
48 Relationship of malnutrition during hospitalization with functional recovery and	Sato et al.	2019	Retrospective observational study	205	Stroke	Prevalence of malnutrition was 42% at admission and 76% at discharge	Use & Utilization	Micro – Individual	Anthropometric data Geriatric Nutritional Risk Index (GNRI)

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Table 3 (continued)

Title	Authors	Year of publication	Study design	Number of participants	Type of disability included	Key findings	Aspect of definition of FNS included	Social level of FNS addressed	Instrument used to assess FNS
49	Shidfar et al.	2016	Cross-sectional study	130	Parkinson's disease	58.5% (n = 76) at risk of malnutrition and 11.5% (n = 15) malnourished according to MNA.	Use & Utilization	Micro – Individual	Anthropometric data Mini Nutritional Assessment – Short Form
50	Shimizu et al.	2019	Retrospective cohort study	188	Stroke	A total of 122 (64.8%) patients were diagnosed with malnutrition	Use & Utilization	Micro – Individual	Anthropometric data Mini Nutritional Assessment – Short Form
51	Silva et al.	2017	Case series study	68	Cerebral palsy	27% underweight, 38.2% stunted, 42.6% malnourished (BMI)	Accessibility Use & Utilization	Micro – Individual	Anthropometric data Food records
52	Takada et al.	2017	Cross-sectional design	259	Dementia		Accessibility Use & Utilization	Micro – Individual	Anthropometric data Food records
53	Tanaka et al.	2019	Retrospective cohort study.	154	Spinal cord injury	71.4% of patients were considered to be malnourished or possibly malnourished	Use & Utilization	Micro – Individual	Anthropometric data Subjective Global Assessment
54	Tsai et al.	2018		542	Schizophrenia	GNRI and OPNI demonstrated a strong association with hospital admission due to infection	Use & Utilization	Micro – Individual	Anthropometric data Geriatric Nutritional Risk Index (GNRI) Onodera's Prognostic Nutritional Index Anthropometric data
55	Wang et al.	2016	Cross-sectional survey	377	Cerebral palsy	160 (42.4%) were stunted, 48 (12.7%) underweight, 81 (21.5%) thin	Use & Utilization	Micro – Individual	Anthropometric data
56	Weun et al.	2019	Single-blinded, randomized controlled trial	45	Stroke	23.3% of male patients and 26.7% of the female patients were malnourished based on MNA categories Majority of the patients were at risk of malnutrition (66.7%)	Accessibility Use & Utilization	Micro – Individual	Anthropometric data Food records Mini Nutritional Assessment – Short Form
57	Yanagimoto et al.	2020	Case study	1	Autism spectrum disorder	Patient was diagnosed with IDA and malnutrition due to avoidant/restrictive food intake disorder (ARFID)	Accessibility Use & Utilization	Micro – Individual and family/ household	Anthropometric data Diet history

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Table 3 (continued)

	Title	Authors	Year of publication	Study design	Number of participants	Type of disability included	Key findings	Aspect of definition of FNS included	Social level of FNS addressed	Instrument used to assess FNS
58	Impact of premorbid malnutrition and dysphagia on ischemic stroke outcome in elderly patients: A community-based study	Aliasghari et al.	2019	Cross-sectional study	253	Stroke	34.3% of the patients were malnourished, 42.2% were at risk of malnutrition, and 23.3% were well nourished.	Use & Utilization	Micro – Individual	Anthropometric data Mini Nutritional Assessment – Short Form
59	Nutritional status in adolescents with esophageal atresia	Birketvedt et al.	2020	Cross-sectional cohort	68	Esophageal atresia	Ten (15%) were classified as stunted Forty-eight (71%) showed daily intake of energy below age-appropriate One-third reported an energy intake below their estimated basal metabolic rate	Accessibility Use & Utilization	Micro – Individual and family/ household	Anthropometric data Diet history
60	Feeding behavior and dietary intake of male children and adolescents with autism spectrum disorder: A case-control study	Castro et al.	2016	Case-control study	49	Autism spectrum disorder	Low height for age and thinness was found more in the group with ASD than among controls	Accessibility Use & Utilization	Micro – Individual and family/ household	Anthropometric data Food records
61	Improving nutritional status of children with cerebral palsy: A qualitative study of caregiver experiences and community-based training in Ghana	Donkor et al.	2019	Qualitative study	17 caregivers 18 children with CP	Cerebral palsy	They felt that the training program had helped reduce this stress and dietary recall data suggested some improved dietary quality; however, there was neither improvement nor deterioration in anthropometric status of the children	Accessibility Use & Utilization	Micro – Individual and family/ household	Anthropometric data Diet history Intervention: Monthly group trainings and home visits, which included guidance on feeding
62	Morbimortality associated to nutritional status and feeding path in children with cerebral palsy	Figuroa et al.	2017	Observational and prospective cohort study	81	Cerebral palsy	37 patients (45.7%) had low weight according to the WHO curves or CDC-NCHS (according to the age of the patient)	Use & Utilization	Micro – Individual	Anthropometric data
63	Vitamin A and vitamin D deficiencies exacerbate symptoms in children with autism spectrum disorders	Guo et al.	2019		ASD: 332 Controls: 197	Autism spectrum disorder	Z-scores of the children with ASD, including ZWA, ZHA ZBMA were significantly lower than those of children in the control group	Use & Utilization	Micro – Individual	Anthropometric data
64	Autistic children: Food habits and the risk of running malnutrition in Morocco	Hafid and Touhamiahami	2018	Descriptive cross-sectional survey	ASD: 325 Controls: 325	Autism spectrum disorder	Underweight ASD 23.38% Control 12.6% according to BMI	Use & Utilization	Micro – Individual	Anthropometric data
65	Multiple nutritional deficiencies in cerebral palsy compounding physical and functional impairments	Hariprasad et al.	2017	Cross-sectional survey	41	Cerebral palsy	34 (82.9%) were severely underweight with weight for age <50% 35 (85.4%) had severe stunting with height for age <85% 38 (92.7%) had severe wasting with weight for height <70% of the expected	Accessibility Use & Utilization	Micro – Individual and family/ household	Anthropometric data Diet history
66	What makes children with cerebral palsy vulnerable to malnutrition? Findings from the	Jahan et al.	2019	Prospective population-based surveillance		Cerebral palsy	Moderately underweight 113 (21.8%) Severely underweight 250	Use & Utilization	Micro – Individual and	Anthropometric data

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Table 3 (continued)

Title	Authors	Year of publication	Study design	Number of participants	Type of disability included	Key findings	Aspect of definition of FNS included	Social level of FNS addressed	Instrument used to assess FNS
Bangladesh Cerebral Palsy Register (BCPR)						(48.2%) Moderately stunted 150 (20.7%) Severely stunted 379 (52.4%) Moderately wasted 39 (15.6%) Severely wasted 52 (20.8%) 43% were malnourished		family/ household	
67 Risk factors for malnutrition among children with cerebral palsy in Botswana	Johnson et al.	2017	Case-control study	61	Cerebral palsy		Use & Utilization	Micro – Individual	Anthropometric data
68 Peer support and food security in deaf college students	Keogh et al.	2020		166	Deaf	26.4% were at risk for low food security 12.9% had very low food security	Accessibility	Micro – Individual and family/ household	US Household Food Security Survey Module
69 Nutritional improvement is associated with better functional outcome in stroke rehabilitation: A cross-sectional study using controlling nutritional status	Kishimoto et al.	2020	Cross-sectional study	134	Stroke	Improvement or maintenance of nutritional status was associated with better functional recovery in post-stroke rehabilitation of adult patients of all ages	Use & Utilization	Micro – Individual	Anthropometric data
70 Feeding problems and nutrient intake in children with and without autism: A comparative study	Malhi et al.	2017	Comparative study	60	Autism spectrum disorder	Height, weight, or body mass index also did not differ for the two groups Despite increased feeding problems reported for the ASD children, no differences were found between the ASD and typically developing children on the overall intake of daily calories	Accessibility Use & Utilization	Micro – Individual and family/ household	Anthropometric data Diet history Food Frequency Questionnaire
71 The intersection of disability and food security: Perspectives of health and humanitarian aid workers	Quarmby and Pillay	2018	Exploratory and descriptive, mixed methods		Various	Highlighted the issue of reduced food security through the mechanism of reduced food access, as not only does it appear that people living with disabilities are dependent on their caregivers for food, but these caregivers appear to bear the burden of disability and food insecurity where financial and time demands are high and resources are few.		Micro – Family/ household	
72 Nutritional profile of multiple sclerosis	Robles et al.	2019	Cross-sectional observational study		Multiple sclerosis	6.5% of patients were at risk of malnutrition (defined as SGA category B) and 1.6% were malnourished (defined as SGA category C) Only a small proportion of patients (25.2%) met the daily energy requirements	Accessibility Use & Utilization	Micro – Individual	Anthropometric data Diet history Subjective Global Assessment
73	Sha'ari et al.	2017	Comparative cross-sectional study	54		According to BMI for age, 11.1% of the ADHD children		Micro – Individual and	

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Table 3 (continued)

Title	Authors	Year of publication	Study design	Number of participants	Type of disability included	Key findings	Aspect of definition of FNS included	Social level of FNS addressed	Instrument used to assess FNS
Nutritional status and feeding problems in pediatric attention deficit-hyperactivity disorder					Attention deficit hyperactivity disorder	had wasting and 1.9% had severe wasting The ADHD subjects consumed more energy and carbohydrate than TD subjects	Accessibility Use & Utilization	family/ household	Anthropometric data Food records
74 “Life just keeps throwing lemons”: The lived experience of food insecurity among Aboriginal people with disabilities in the West Kimberley	Spurway and Soldatic	2016		16	Unspecified	Lack of government provisioning around health, housing and disability services and supports compounded the poor opportunities in the local labour market, due to both disability and race discrimination, and the high cost of living	Availability Accessibility Use & Utilization Stability	Meso (Community) – District/Town	
75 Zinc and vitamin A deficiency in a cohort of children with autism spectrum disorder	Sweetman et al.	2019		74	Autism spectrum disorder	The mean (SD) vitamin A level was significantly higher in the ASD group than in the control group	Use & Utilization	Micro – Individual	
76 Factors associated with post-stroke nutritional status in stroke survivors under rehabilitation	Ying et al.	2019	Cross-sectional study	169	Stroke	Prevalence of malnutrition was 8.9% Older age stroke survivors were at a 10% higher risk of becoming malnourished compared to younger stroke survivors	Use & Utilization	Micro – Individual	Anthropometric data

Table 4
Summary of measures of FNS used in included studies.

Measure of FNS	Findings	Studies
1 Mini Nutritional Assessment (MNA)	Stroke patients: <ul style="list-style-type: none"> • 34.3% – malnourished • 42.2% – at risk of malnutrition • 23.3% well nourished (Aliasghari et al., 2019) • Risk of malnutrition increased from 13.4% to 17.1% after three months Malnutrition increased from 0.6% to 1.2% (Barrio et al., 2020) <ul style="list-style-type: none"> • 99% – at risk of malnutrition (Nishioka et al., 2017) • 29.8% – malnourished (Nishioka et al., 2020); • 64.8% – diagnosed with malnutrition (Shimizu et al., 2019) • 3.3% of male stroke patients and 26.7% of female stroke patients – malnourished (Weun et al., 2019) Intellectual disability: <ul style="list-style-type: none"> • More than 50% of women – at risk of malnutrition • 15% – malnourished (Alkazemi et al., 2018) Alzheimers: <ul style="list-style-type: none"> • 65.6% – at risk of malnutrition • 3.1% – malnourished (Dos Santos et al., 2018). Cerebral palsy: <ul style="list-style-type: none"> • More than 80% – malnourished or at risk of malnutrition (Norte et al., 2019). Parkinson's Disease: <ul style="list-style-type: none"> • 58.5% – at risk of malnutrition • 11.5% – malnourished (Shidfar et al., 2016). 	Aliasghari et al. (2019); Alkazemi et al. (2018); Barrio et al. (2020); Dos Santos et al., 2018; Nishioka et al. (2017); Nishioka et al. (2020); Norte et al. (2019); Shidfar et al. (2016); Shimizu et al. (2019); Weun et al. (2019).
2 Geriatric Nutritional Risk Index (GNRI)	Prevalence of malnutrition in stroke patients was 42% at admission and 76% at discharge (Sato et al., 2019).	Nishioka et al. (2020); Sato et al. (2019); Tsai et al. (2018)
3 Subjective Global Assessment	Multiple Sclerosis: 6.5% of patients – at risk of malnutrition 1.6% – malnourished (Robles et al., 2019) Spinal cord injury: 71.4% – malnourished or possibly malnourished (Tanaka et al., 2019)	Redondo Robles et al., 2019; Tanaka et al. (2019)
4 Coping Strategy Index	87.5% of participants with physical, visual, speech or hearing disabilities – chronically food insecure 5% of participants – food secure	Endale & Tolossa (2017)
5 Australian Nutrition Screening Initiative Checklist	17.6% of participants with ID fell in the high-risk category for malnutrition	Koritsas & Iacono (2016)
6 US Household Food Security Survey Module	17.6% of participants with hearing disabilities – in the high-risk category for food insecurity	Kushalnagar et al. (2018)
7 Subjective Global Nutrition Assessment (SGNA)	22% of children with CP – moderately undernourished 7% – severely undernourished	Bell et al. (2019)
8 Parent Nutrition	48.88% of patients with developmental disabilities	Malone et al. (2016)

Table 4 (continued)

Measure of FNS	Findings	Studies
9 Screening Checklist (PNSC)	– at moderate or high nutritional risk 16.87% – in the high nutritional risk category	Nishioka et al. (2020)
10 Malnutrition Universal Screening Tool	The combination of measures used showed 29.8% of stroke patients were malnourished.	
11 ESPEN - Diagnostic Criteria for Malnutrition	GNRI and OPNI demonstrated a strong association with hospital admission due to infection in patients with schizophrenia.	Tsai et al. (2018)

2019a,b); Vietnam (Karim et al., 2019); Poland (Kijowska et al., 2020); Tanzania (Mlinda et al., 2018); Bosnia and Herzegovina (Melunovic et al., 2017); Nigeria (Ogumjima and Ajala, 2016); Norway (Birketvedt et al., 2020); Saudi Arabia (Almuneef et al., 2019); Turkey (Aydin et al., 2019); Bangladesh (Jahan et al., 2019a,b); Botswana (Johnson et al., 2017) and Ireland (Sweetman et al., 2019). Two of the included studies were conducted across multiple countries (Lefranc et al., 2016; Quarumby and Pillay, 2018).

The majority of studies (n = 44) involved children and 25 involved adults (see age of participants in Table 3). Three studies included samples from both children and adults, while four studies did not specify the age of participants. The types of disabilities mostly included were Cerebral Palsy (n = 24), Autism Spectrum Disorder (ASD) (n = 13) and Persons living with stroke (n = 11).

Fifty studies were conducted in hospital, rehabilitation or outpatient centre settings, while seven studies were conducted in communities.

The majority (n = 61) of included studies focused on the person with disability, while 11 studies involved persons with disabilities but used measures that required input from both the caregiver and the person with disability. One study used a measure that focused on the households of persons with disabilities, another dealt with persons with disabilities and disability workers, another with healthcare workers and humanitarian aid workers, and one study focused on persons with disabilities as well as municipalities and food vendors.

3.2. Mapping the literature according to the determinants of FNS addressed

Only two studies (Endale and Tolossa, 2017; Spurway and Soldatic, 2016) included the component of availability as a determinant of FNS, which relates to adequate food being at people's disposal (Gross et al., 2000). Endale and Tolossa (2017) reported that in Hawassa town, Ethiopia, periods of food shortage affected the food choices of households and more so the households of persons with disabilities. In rural Australia, aboriginal persons with disabilities struggled with the availability of food due to uneven distribution of supermarkets, poor quality of food stocked, and the unaffordable prices of nutritious food (Spurway and Soldatic, 2016).

More studies included accessibility as a determinant of FNS (n = 26). Accessibility in this context refers to households and individuals within households having sufficient resources to obtain appropriate foods for a nutritious diet (Gross et al., 2000). Indicators of FNS relating specifically to the dimension of accessibility include meal frequency and food frequency (Gross et al., 2000) where participants were required to use a checklist to indicate how often they ate specific food items over a specified period. Food frequency questionnaires were used as indicators

of FNS in six of the included studies (Caramico-Favero et al., 2018; Endale and Tolossa, 2017; Fuentes-Albero et al., 2019; Malhi et al., 2017; Martinez et al., 2018; Meguid et al., 2017; Moludi et al., 2019). Some studies (n = 10) made use of 2-to 4-day food records to measure accessibility (Almuneef et al., 2019; Birketvedt et al., 2020; Castro et al., 2016; Holton et al., 2019; Liu et al., 2016; Malhi et al., 2017; Martinez et al., 2018; Sha'ari et al., 2017; Takada et al., 2017; Yanagimoto et al., 2020). Accessibility was measured by 24-h dietary recalls in nine studies (Ahmad et al., 2020; Barja and Perez, 2016; Donkor et al., 2019; Hariprasad et al., 2017; Holton et al., 2019; Liu et al., 2016; Silva et al., 2017; Weun et al., 2019), where participants were required to recall everything they consumed in a 24-h period.

Only a limited number of included studies described some of the barriers to food access as described in Schwartz et al. (2019) review. According to Bualar (2016) some persons with disabilities in Thailand desired to participate in paid jobs, which they felt would secure their access to food. In their study on persons who are Deaf in the USA, Kushalnagar et al. (2018) reported that up to 28% of participants sometimes experienced problems buying food or making food last, while a further 8% reported experiencing this often, highlighting challenges to access food. In another US study, about 26.4% of deaf students were at risk of low food security and a further 12.9% had very low food security (Keogh et al., 2020). This highlights an under representation in the literature of the unique challenges experienced by persons with disabilities in securing access to food.

Use and utilization, referring to the ability of the human body to ingest and metabolize food, was assessed using anthropometric data (Gross et al., 2000). Anthropometric data, the most common indicator of FNS across all the studies, was used in 58 of the 76 studies. Anthropometric data included, but was not limited to, weight for age, height for age, weight for height, BMI and BMI for age. Nutrient deficiencies, also indicators of the use and utilization dimension of FNS, were reported in nine studies indicating Vitamin A deficiency (Liu et al., 2016); Vitamin D deficiency (Leonard et al., 2020; Liu et al., 2016); Vitamin C deficiency (Coppini et al., 2018; Hafid and Touhamiahami, 2018; Raffee et al., 2019); iron deficiency (Hafid and Touhamiahami, 2018; Hariprasad et al., 2017; Leonard et al., 2020; Liu et al., 2016; Yanagimoto et al., 2020) and other trace element deficiencies (Bebars et al., 2019; Hafid and Touhamiahami, 2018; Leonard et al., 2020; Liu et al., 2016).

Liu et al. (2016) found that children with ASD had higher rates of Vitamin A and iron deficiency, while Hafid and Touhamiahami (2018) found higher rates of vitamin deficiencies among these children compared to controls. Raffee et al. (2019) attributed the higher risk of micronutrient deficiencies in children with ASD to the limited diversity of their food intake.

Most studies focusing on the nutritional status of persons with disabilities found an increased risk of malnutrition across most types of disabilities and ages, with some studies showing that more than 80% of the sample population suffered some degree of malnutrition according to the WHO (Aydin et al., 2019). Only four studies showed a low risk of malnutrition in their study populations, which included the following disabilities: intellectual disabilities (Koritsas and Iacono, 2016); ADHD (Fuentes-Albero et al., 2019); ASD (Moludi et al., 2019) and stroke (Ying et al., 2019).

In their assessment of food security status of persons with disabilities in Ethiopia, Endale and Tolossa (2017) differentiated between food security, seasonal food insecurity and chronic food insecurity, highlighting **stability** as a determinant of FNS. Of the 80 participants (persons with physical, visual, speech and hearing disabilities), none were found to be food secure and up to 87.5% were found to be chronically food insecure.

3.3. Describing assessment, indicators and interventions of FNS

3.3.1. Assessments and indicators of FNS

Measures of FNS utilized in the included studies included the

Subjective Global Nutrition Assessment (SGNA) (Bell et al., 2019); Subjective Global Assessment (SGA) (Tanaka et al., 2019; Redondo Robles et al., 2019); Mini Nutritional Assessment – Short Form (MNA-SF) (Alkazemi et al., 2018; Dos Santos et al., 2018; Nishioka et al., 2020; Nishioka et al., 2017; Norte et al., 2019; Barrio et al., 2020; Shidfar et al., 2016; Shimizu et al., 2019; Weun et al., 2019; Aliasghari et al., 2019); Coping Strategy Index (CSI) (Endale and Tolossa, 2017); Australian Nutrition Screening Initiative checklist (Koritsas and Iacono, 2016); US Household Food Security Survey Module (Kushalnagar et al., 2018); Parent Nutrition Screening Checklist (PNSC) (Malone et al., 2016); Malnutrition Universal Screening Tool (MUST) (Nishioka et al., 2020); Geriatric Nutritional Risk Index (GNRI) (Nishioka et al., 2020; Sato et al., 2019; Tsai et al., 2018); ESPEN Diagnostic Criteria for malnutrition (Nishioka et al., 2020); and Onodera's Prognostic Nutritional Index (Tsai et al., 2018).

The majority of the above measures were designed for elderly or general populations, and only a limited number were intended specifically for or validated for use with persons with disabilities. For example, the SGNA established validity for assessing nutritional status in children with a wide range of conditions and older than one month, including children with CP and Down's syndrome (Secker and Jeejeebhoy, 2007). The PNSC, a validated parent administered screening tool specifically for children with special needs, was used to assess nutritional risk in children over the age of one year presenting with developmental delay (Malone et al., 2016). In a sample of 415 children with developmental disabilities, a total 48.88% of patients were at moderate or high nutritional risk according to the PNSC (Malone et al., 2016).

3.3.2. FNS interventions instruments

A limited number of studies (n = 2) addressed intervention for FNS by means of the WHO Severe Acute Malnutrition Protocol (Bebars et al., 2019) and nutritional education sessions for caregivers of children with CP (Donkor et al., 2019; Mlinda et al., 2018). Bebars et al. (2019) found that the WHO Severe Acute Malnutrition Protocol was effective in improving the serum levels of micronutrients in malnourished children with CP, but that children with CP required additional micronutrient supplementation to avoid further complications associated with micronutrient deficiency. Donkor et al. (2019) found that the training program was effective in alleviating caregiver stress and although the dietary recall data suggested that there was an improvement in dietary quality, no improvement in nutritional status was documented. Mlinda et al. (2018) concluded that a practical nutrition education intervention can improve caregiver-feeding skills for children with CP in low-income countries.

Most studies included in the review (n = 73) addressed the micro level of social organization which relates to individuals and families or households (Gross et al., 2000). The remaining three studies addressed the meso level of organization, which relates to the community (provinces, cities, districts, towns and villages) (Gross et al., 2000). None of the studies included addressed any of the dimensions of FNS on a national or global (macro) level.

Altogether 56 of the 76 studies focused on the person with the disability alone by assessing the nutritional status or dietary intake of individuals. An additional 13 studies included families and households by requesting caregivers to report on their child's dietary intake or assessed the food frequency of the family or household. A small number of studies focused solely on the family or household by investigating FNS challenges for caregivers of persons with disabilities (Malhi et al., 2017) and intervention studies for their caregivers (Donkor et al., 2019; Mlinda et al., 2018).

4. Concluding remarks

Food and nutrition security combines the concepts of food security and nutrition security. It shifts the focus away from one or the other, and the use and utilization of food in the definition of FNS highlights the

biological aspect of FNS as opposed to only a physical aspect of food availability and access (Gross et al., 2000). This review however found that all the studies included either addressed food security or nutrition security, and none of them considered food and nutrition security as a combined construct for people with disabilities. The vast majority of studies focused on nutrition security in persons with disabilities, and only four studies looked at food security of persons with disabilities. This shows a significant gap in the literature.

The aim of the review, in part, was to map existing literature on FNS and disability, according to the determinant of FNS and the level of social organization addressed. The review found that the literature is unevenly distributed in both respects. The majority of studies included in the review assessed the nutritional status of persons with disabilities, focusing mostly on the use and utilization aspect of FNS, and honing in on the situation at the individual (micro) level. As the included studies mostly focused on the use and utilization of food, little is known about the availability of and access to food for persons with disabilities, and even less is known on the challenges their caregivers face in accessing nutritious food. The unique challenges to accessing food experienced by persons with disabilities is still poorly understood. Schwartz et al. (2019) argue that questioning why persons with disabilities experience greater financial deprivation, social discrimination and environmental barriers will lead to a better understanding of food access in the context of persons with disabilities.

Eleven different measures were used to assess nutritional risk in a range of disability conditions, but only two – the SGNA and PNSC – were designed or validated specifically for persons with disabilities, thus highlighting a gap in the measures of FNS for persons with disabilities. High risk of malnutrition was reported in several studies using the various measures as listed, but as mentioned, the risk of malnutrition is higher among persons with disabilities compared to the general population. Indicators and measures of FNS should be sensitive and specific to persons with disabilities to provide a more accurate picture of the risk of malnutrition in this population.

The gaps in the literature identified in the review highlight various opportunities for further research. Future research should identify relevant indicators, measures of assessment and instruments for intervention for persons with disabilities. While there are limited measures of food security and nutrition security as separate concepts, there is a need for measures that address both. Identifying the extent of FNS at various levels of social organization and focusing more on meso and macro levels should be a priority in future research, as it will aid in developing interventions to address food and nutrition insecurity on a larger scale.

Limitations of this review include language and publication biases, as only studies published in English were included. Although the search terms were established in consultation with two subject librarians and piloted, there is still a possibility that some disability groups may have been excluded from the search. The review's aim to provide a global perspective on FNS and disabilities may have been hampered by the exclusion of studies published in other languages or studies that the authors were not able to access through the University of Pretoria's library online.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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