Original Article

Imputed food insecurity as a predictor of disease and mental health in Taiwanese elementary school children

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This study investigated the association between food insecurity and Taiwanese children's ambulatory medical care use for treating eighteen disease types linked to endocrine and metabolic disorders, nutrition, immunity, infections, asthma, mental health, injury, and poisoning. We used longitudinal data in the Taiwan National Health Insurance scheme (NHI) for 764,526 elementary children, and employed approximate NHI data to construct three indicators imputed to food insecurity: low birth weight status, economic status (poverty versus non-poverty), and time of year (summer break time versus semester time). We compared ambulatory care for these diseases between children with low birth weight and those not, and between children living in poverty and those not. A difference-in-differences method was adopted to examine the potential for a publicly- funded lunch program to reduce the harmful health effects of food insecurity on poor children. We found that children in poverty were significantly more likely to have ambulatory visits linked with diabetes, inherited disorders of metabolism, iron deficiency anemias, ill-defined symptoms concerning nutrition, metabolism and development, as well as mental disorders. Children with low birth weight also had a significantly higher likelihood of using care for other endocrine disorders and nutritional deficiencies, in addition to the above diseases. The study failed to find any significant effect of the semester school lunch program on alleviating the harmful health effects of food insecurity for poor children, suggesting that a more intensive food program or other program approaches might be required to help poor children overcome food insecurity and its related health outcomes.

Key Words: food insecurity, disease, mental health, health expenditure, children

INTRODUCTION

Food insecurity is a prevalent problem worldwide. It has been reported that about one seventh of the world's population suffered from food insufficiency in the early 2000s.[1] As food security is related to nutrient intake, it can subsequently affect disease expression. Over recent years, survey instruments for measuring food security have been developed and used in empirical studies exploring consequences of and contributors to food insecurity.[2-5] In particular, the US government developed the US Food Security Survey Module (US FSSM) in the 1990s, and has been using it to collect data concerning food security since 1995.[6] According to the official conceptual definition of the US government, food insecurity refers to shortage of food due to financial difficulties.[6] The US FSSM was designed to measure the operational conditions reflecting such a concept. It is reliable,[7] and data collected by this instrument show a strong link between food insecurity and income level under the poverty line.[8]

Some researchers argue that food insecurity is a risk factor for poor child health and behavioural problems.[6] There is an association between food insecurity and a decline in children's health status as reported by caregivers, as well as an effect of food insecurity on increasing the chances of being hospitalised after birth.[3] With food insecurity there is also a larger likelihood of being underweight during childhood,[4] lower self-reported quality of life for children,[2] and suboptimal physical and psychosocial functions among children.[2]

Risk factors for food insecurity or insufficiency for children include low household economic status [1,4,8,9] and urban residential environment.[1,10,11] Low economic status, in addition to being related to food insecurity, has been identified as a contributor to severe malnutrition in childhood.[12] Publicly- funded food aid targeted at poor households, such as the Food Stamp Program in the US, has been found helpful in alleviating the adverse effects of food insecurity on child health and hospitalisations, although it was unable to eliminate such inequalities.[3]

Through various physical, physiological or socio-behavioural mechanisms, all systems of the human body

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respond to food intake and nutritional status.[13] Thus, any system can be influenced by food insecurity. Although it is well recognized that food insecurity is related to health, there has been little research focusing on the associations of food insecurity with specific diseases. This research specifically investigated ambulatory medical care use associated with malnutrition, endocrine and metabolic disorders, immune disorders, overt nutritional deficiency, infections, asthma, mental disorders, injury, and poisoning among Taiwanese elementary school children under the Taiwan National Health Insurance (NHI) system, which has a coverage rate close to 100%. Eighteen disease types were selected for analysis: (1) disorders of the thyroid gland; (2) diabetes mellitus; (3) diseases of other endocrine glands; (4) protein-energy malnutrition; (5) nutritional deficiencies other than protein-energy malnutrition; (6) inherited disorders of metabolism; (7) obesity and other hyperalimentation; (8) immune disorders; (9) iron deficiency anemias; (10) ill-defined symptoms concerning nutrition, metabolism, and development; (11) intestinal infectious diseases; (12) tuberculosis; (13) upper respiratory infections; (14) lower respiratory infections; (15) asthma; (16) mental disorders; (17) injury; and (18) poisoning.

The main purpose of the present study is to explore the association between imputed food insecurity and expression of the aforementioned diseases. The NHI data are administrative data without information on food insecurity. We used approximate information in the NHI data to construct three indicators associated with food insecurity: birth weight status (with low birth weight or not), economic status (poverty versus non-poverty), and time of year (summer break time versus semester time). As the indicators of food insecurity we used were based on NHI data reflecting maternal nutritional status during pregnancy (low birth weight), family income, and time period regarding lunch program operation, rather than self-reported survey data to measure food insecurity, we termed these indicators "imputed food insecurity."

These imputed food insecurity indicators reflect three risk domains for children: family food insecurity before birth, family food insecurity after birth, and a weak food aid program in childhood (Figure 1). The levels of the three risks can be measured approximately by using the NHI data. The central idea of this study is to take advantage of this opportunity to investigate how these risk domains affect child health.

Low birth weight is linked to maternal under- nutrition during pregnancy,[14,15] and it is thus one indicator of a child's food insecurity at the embryonic or fetal stage (before birth). By examining whether children with low birth weight used more ambulatory medical care linked with the eighteen disease types, we could explore associations between family food insecurity and these diseases. Poor children have significantly higher risk of facing food insecurity,[1,4,8,9] and poverty can thus be an indicator of considerable food insecurity after birth. By comparing ambulatory medical use linked with the eighteen disease types between children living in poverty and those not, we could explore associations between family food insecurity in childhood and these diseases.

Successful food aid programs can decrease the adverse health effects of food insecurity for children, especially for poor ones. However, some program approaches may be too weak to produce substantial benefits for child health. The Taiwan government operates a lunch program in all public elementary school during the semester. Each school is responsible for choosing a healthy and affordable lunch package, and school kitchens or contracted restaurants prepare lunches accordingly. Poor children's lunch fees are totally paid by the government. It is thus expected that poor children experience food insecurity to lesser degree during the semester than in summer break time. By examining difference in ambulatory medical care use linked with the aforementioned diseases between the summer break and school semester, and further investigating degrees of such differences among children with varied economic conditions, we could explore the effect of the publicly-funded lunch program to reduce the harmful health effects of food insecurity for poor children.

MATERIALS AND METHODS

We used NHI registration and ambulatory care data of all children born between January 1, 1997 and August 31, 1999. All the children had highly reliable NHI data for any time point after birth. Considering that the 2006 summer was the first summer when all these children were in elementary school, this study focused on investigating their ambulatory medial care use for the eighteen disease types during the summer breaks and fall semesters of 2006 and 2007.

The period from August 1 to September 30 was se-

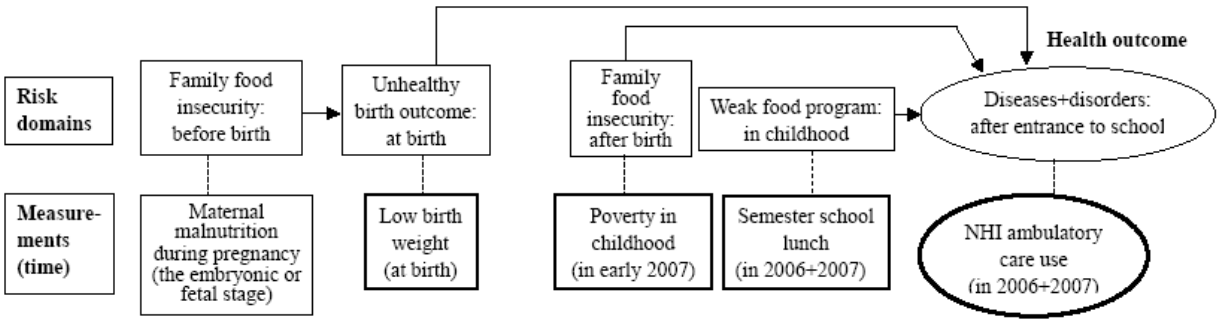

Figure 1. Analytical pathway which links imputed family unit food insecurity to nutritionally- related disorders and diseases (NRD) through low birth weight, low economic status, and weak food aid programs

lected to represent summer break, and the period from November 1 to December 31 was chosen to represent the school semester of the same length. We did not include July in the period representing summer break, since the beneficial effect of a semester lunch program, if any, may still influence a child's health in the first few weeks of the summer break. Further, to take into account that the accumulated effect of the absence of the publicly- funded lunch in summer may not disappear until some time after the new fall semester, we included the first two weeks of the fall semester in the period which represented the summer break.

Each child in our analysis was categorised into a specific economic group. We identified children under the poverty line based on the 2007 NHI records of families with income below the poverty line defined by the Taiwan Bureau of National Health Insurance (BNHI). For ranking above the poverty line, we used the 2007 April records of household income which the BNHI used to calculate each child's NHI premium level. Four economic categories were defined: below the poverty line defined by the Taiwan government (the bottom 1.9% of the children fell into this category), low-income but above the poverty line (1.9%~24.4% from the bottom, including 22.5% of the children), middle-income (including 50.3% of the children), and upper-income (upper 25.4% of the children) (Table 1). We separated children under the poverty line from other children in the bottom 25% of household income distribution, as they might face the most serious food insecurity among low-income children, while they are also the only group among low-income children to receive a special NHI benefit, namely exemption from NHI premiums and co-payments.

For each disease type, we counted each child's ambulatory visits and calculated their expenditures, separately for summer breaks of 2006-2007 combined and the same duration of the following school semester of 2006-2007 combined. We then estimated the following outcome variables separately for each economic group and each time type (i.e., two-way classification based on economic status and semester or vacation time): (1) the incidence rate; (2) per capita expenditures of the whole sample; and (3) per capita expenditures of children using ambulatory care. For each economic group, we examined difference between the summer break and the school semester, and further conducted analysis of difference-in-differences to compare such difference for high-income children with differences of the other three groups.

We used the random-effects logit regression model to examine factors associated with a child's likelihood of using ambulatory care for a specific disease type during the summer break or fall semester of 2006-2007. Adjusted odds ratios (OR) estimated by the random-effects logit regression models were used to examine the strength of various factors. For children using ambulatory care, we adopted the random-effects linear regression model to investigate factors associated with the expense on a specific disease type during the summer break or fall semester of 2006-2007, using the natural log of expenses as the outcome variable. Coefficients estimated by the random-effects linear regression models were transformed by the exponential function to show the adjusted relative ratios (RR) of expense, which could reflect disease severity among children using care.

We used International Classification of Diseases, Ninth Revision (ICD-9-CM) codes to identify ambulatory care linked with the 18 disease or disorder types: (1) disorders of thyroid gland (ICD-9 codes=240~246); (2) diabetes mellitus (250); (3) diseases of other endocrine glands (251~259); (4) protein-energy malnutrition (260~263); (5) nutritional deficiencies other than protein-energy malnutrition (264~269); (6) inherited disorders of metabolism (270~277); (7) obesity and other hyperalimentation (278); (8) immune disorders (279); (9) iron deficiency anaemias (280); (10) ill-defined symptoms concerning nutrition, metabolism, and development (783);

Table 1. Subject characteristics

Characteristic	Total (n=764,526, 100.0%)		Poverty (n=14,617, 1.9%)		Low income (n=171,650, 22.5%)		Middle income (n=384,366, 50.3%)		High income (n=193,893, 25.4%)	
	n	%	n	%	n	%	n	%	n	%
Gender										
Boy	398,518	52.13	7,354	50.31	89,236	51.99	200,562	52.18	101,366	52.28
Girl	366,008	47.87	7,263	49.69	82,414	48.01	183,804	47.82	92,527	47.72
NHI registration area										
North	368,789	48.24	5,957	40.75	74,134	43.19	164,993	42.93	123,705	63.80
Central	154,228	20.17	2,011	13.76	42,862	24.97	81,249	21.14	28,106	14.50
South	222,361	29.08	4,793	32.79	49,696	28.95	129,067	33.58	38,805	20.01
East	19,148	2.50	1,856	12.70	4,958	2.89	9,057	2.36	3,277	1.69
Urbanization level of NHI registration location										
Large city	369,139	48.28	5,853	40.04	82,906	48.30	161,641	42.05	118,739	61.24
Small city or town	289,690	37.89	4,415	30.20	68,907	40.14	155,199	40.38	61,169	31.55
Rural area	105,697	13.83	4,349	29.75	19,837	11.56	67,526	17.57	13,985	7.21
Low birth weight										
Yes	6,121	0.80	169	1.16	1,261	0.73	3,013	0.78	1,678	0.87
No	758,405	99.20	14,448	98.84	170,389	99.27	381,353	99.22	192,215	99.13
Number of ambulatory visits during the first week of life										
0	730,138	95.50	13,911	95.17	164,102	95.60	366,160	95.26	185,965	95.91
1	29,829	3.90	611	4.18	6,574	3.83	15,711	4.09	6,933	3.58
2 or more	4,559	0.60	95	0.65	974	0.57	2,495	0.65	995	0.51

(11) intestinal infectious diseases (001~009); (12) tuberculosis (010~018); (13) upper respiratory infections (460~466); (14) lower respiratory infections (480~487); (15) asthma (493); (16) mental disorders (290~319); (17) injury (800~959); and (18) poisoning (960~979).

Other information gathered for this study included NHI registration location, low birth weight status, the number of ambulatory visits during the first week of life, and gender. Our final sample size was 764,526, and the sample characteristics are reported in Table 1. These variables are tied to health production, and we used them as control variables in the multivariate analysis to investigate disparity among economic groups and the effect of the publicly- funded lunch program to decrease such disparity. The NHI registration location was used to reflect local environmental conditions (regional culture and urbanization level). Low birth weight status, number of ambulatory visits during the first week of life, and gender were used to capture some of the innate heterogeneity. We added two types of interaction terms in the multivariate analysis: (1) break time*economic status; (2) low birth weight*poverty. The first type of interaction terms was used to examine whether economic inequality in medical care use for these diseases differed between break time and semester time, and to further explore whether the publicly- funded lunch program helped in reducing economic disparity regarding food insecurity. The second type was used to investigate whether a combination of low birth weight and poverty aggravated the harmful health effects of poverty and of low birth weight, if any.

It should be noted that the NHI registration location for a child is based on the primary caregiver's employer or union responsible for filing their NHI registration data. Therefore, the NHI registration location does not necessarily reflect the local environment where a child actually lives. Nonetheless, we believe that this location indicator can capture environmental influences for most children, since one report of the Taiwan Department of Health shows a very similar distribution of living environment in 2007 for children born in 2000, based on Taiwan's 2007 household registration data: 45.1%, 41.0% and 13.9% in large cities, small cities/towns, and rural areas, respectively.[16] Our data show that 48.3%, 37.9%, and 13.8% of children born in 1997-1999 lived in large cities, small cities/towns, and rural areas in 2007, respectively.

With regard to low birth weight status, we referred to the NHI data on whether a child received any NHI healthcare with low birth weight as a diagnosis. Accordingly, we were thus not able to identify children who might have had low birth weight but did not have a record of low birth weight recorded when in receipt of medical care. Our data show an underestimation of the incidence of low birth weight (<2500 g), as governmental statistics indicate that 6% of children born in 1997 had low birth weight.[17] It is likely that children identified as low birth weight cases in this study were those with very low birth weight.

RESULTS

The majority of children used ambulatory care linked to upper respiratory infections (around 58% of the whole sample during the summer break), and a substantial proportion of children had ambulatory visits for injury (around 8%); the proportions with regard to lower respiratory infections and to mental disorders were modest (3.2% and 2.3%, respectively); in contrast, only less than 1% of children used ambulatory care to treat diseases associated with endocrine and metabolic disorder, protein-energy malnutrition, nutritional deficiencies, and immune disorders (Table 2). Even so, children living in poverty were more likely to use ambulatory care linked to diabetes, inherited disorders of metabolism, iron deficiency anemias, ill-defined symptoms concerning nutrition, metabolism and development (Table 2). The proportions undertaking ambulatory visits associated with mental health and injury were also higher among children living in poverty (Table 2).

No obvious difference in the probability of seeking ambulatory care was observed between the summer break and fall semester, except for upper respiratory infections (Table 2). The descriptive difference-in-differences analysis does not suggest an effect of the semester-dependent publicly-funded lunch program on reducing harmful health effects of food insecurity for poor children, except for per capital expenditures, which could reflect disease severity, of children using ambulatory care for thyroid disorders, diseases of other endocrine glands, and protein-energy malnutrition (see DD1 for these items; Table 2).

Adjusted OR's estimated by the random-effects logit regression models confirm that children in poverty were more likely to have ambulatory visits linked with diabetes (OR=1.87), inherited disorders of metabolism (OR=1.94), iron deficiency anamias (OR=2.68), and ill-defined symptoms concerning nutrition, metabolism and development (OR=2.02) (Table 3). Children living in poverty also had a significantly higher likelihood of using ambulatory care to treat mental disorders (OR=2.29), and a substantially larger probability of receiving ambulatory care for injury (OR=1.52). Nonetheless, adjusted OR's with regard to interaction terms combining time of year and economic status suggest that poverty-related disparity in the probability of seeking ambulatory care did not decrease during the semester.

As expected, children with care linked to a low birth weight had a greater likelihood of using ambulatory care for several diseases. Particularly, these children were significantly more likely to have ambulatory visits linked with thyroid disorders (OR=2.68), diseases of other endocrine glands (OR=2.95), protein-energy malnutrition (OR=2.68), nutritional deficiencies other than protein-energy malnutrition (OR=3.40), inherited disorders of metabolism (OR=2.12), iron deficiency anemias (OR= 3.75), ill-defined symptoms concerning nutrition, metabolism, and development (OR=3.92), and mental disorders (OR=4.51). Children with care for low birth weight also had a higher likelihood of using ambulatory care for upper respiratory infections (OR=1.36), lower respiratory infections (OR=1.30), and asthma (OR=1.67), but the strength of influence of low birth weight was lower than that with regard to endocrine and metabolic disorders, protein-energy malnutrition, nutritional deficiencies, and mental disorders.

Table 2. Children's ambulatory care use for the eighteen disease types

	Poverty (N=14617)			Near poverty (N=171650)			Middle income (N=384366)			High income (N=193893)			DD1‡	DD2‡	DD3‡
	Break time	School time	Diff†	Break time	School time	Diff†	Break time	School time	Diff†	Break time	School time	Diff†			
1 Thyroid disorders															
% of children having visits	0.09	0.09	0.00	0.09	0.08	0.01	0.09	0.08	0.01	0.09	0.10	-0.01	0.01	0.02	0.02
Per capita expenditure (NTD)	11.0	7.4	3.6	3.4	2.5	0.9	4.3	3.2	1.1	3.1	3.0	0.0	3.6	0.8	1.1
Per capita expenditure of children using care (NTD)	12,364	8,274	4,090	3,546	3,077	469	4,760	3,750	1,010	3,352	3,093	260	3,831	209	751
2 Diabetes mellitus															
% of children having visits	0.14	0.10	0.04	0.06	0.06	0.00	0.06	0.05	0.01	0.06	0.06	0.00	0.04	0.00	0.01
Per capita expenditure (NTD)	7.5	5.2	2.3	3.4	2.8	0.6	2.7	2.3	0.4	3.5	2.8	0.7	1.6	-0.1	-0.3
Per capita expenditure of children using care (NTD)	5,507	5,474	32	5,613	5,003	610	4,909	4,523	385	5,407	4,883	524	-492	86	-139
3 Diseases of other endocrine glands															
% of children having visits	0.28	0.26	0.02	0.27	0.23	0.04	0.32	0.28	0.04	0.55	0.44	0.11	-0.09	-0.07	-0.07
Per capita expenditure (NTD)	23.2	17.4	5.8	18.1	16.0	2.1	24.4	21.1	3.3	33.0	26.7	6.3	-0.6	-4.2	-3.0
Per capita expenditure of children using care (NTD)	8,260	6,691	1,569	6,668	7,042	-374	7,579	7,552	27	6,019	6,055	-36.1	1,605	-338	63
4 Protein-energy malnutrition															
% of children having visits	0.03	0.03	0.00	0.03	0.03	0.00	0.03	0.04	-0.01	0.03	0.04	-0.01	0.01	0.01	0.00
Per capita expenditure (NTD)	1.1	0.5	0.6	1.0	1.1	-0.1	1.6	1.6	0.0	0.4	0.6	-0.2	0.7	0.1	0.2
Per capita expenditure of children using care (NTD)	3,088	1,442	1,646	3,143	4,206	-1,063	4,726	4,214	512	1,130	1,544	-414	2,060	-650	925
5 Nutritional deficiencies other than protein-energy malnutrition															
% of children having visits	0.05	0.05	0.00	0.01	0.02	-0.01	0.02	0.03	-0.01	0.03	0.03	0.00	0.00	-0.01	-0.01
Per capita expenditure (NTD)	0.4	0.7	-0.2	0.4	0.3	0.1	0.4	0.3	0.1	0.8	0.4	0.4	-0.7	-0.4	-0.3
Per capita expenditure of children using care (NTD)	930	1,428	-499	2,898	1,827	1,071	1,552	1,004	548	3,055	1,257	1,799	-2,297	-728	-1,251
6 Inherited disorders of metabolism															
% of children having visits	0.49	0.51	-0.02	0.18	0.23	-0.05	0.20	0.27	-0.07	0.23	0.28	-0.05	0.03	0.00	-0.02
Per capita expenditure (NTD)	13.2	12.6	0.6	6.2	6.6	-0.5	11.9	13.6	-1.7	80.0	82.9	-3.0	3.5	2.5	1.3
Per capita expenditure of children using care (NTD)	2,679	2,497	182	3,362	2,871	491	5,951	5,057	895	35,002§	29,128§	5,874	-5,692	-5,383	-4,980

See footnotes at the bottom of the table.

Table 2. (cont.)

	Poverty (N=14617)			Near poverty (N=171650)			Middle income (N=384366)			High income (N=193893)			DD1‡	DD2‡	DD3‡
	Break time	School time	Diff.†	Break time	School time	Diff.†	Break time	School time	Diff.†	Break time	School time	Diff†			
7 Obesity and other hyperalimentation															
% of children having visits	0.09	0.08	0.01	0.05	0.05	0.00	0.06	0.05	0.01	0.07	0.07	0.00	0.01	0.00	0.01
Per capita expenditure (NTD)	1.3	0.9	0.4	1.7	1.2	0.4	1.6	1.0	0.5	1.1	1.1	0.0	0.5	0.5	0.6
Per capita expenditure of children using care (NTD)	1,482	1,099	384	3,387	2,551	835	2,557	2,038	518	1,680	1,643	37	346	798	481
8 Immune disorders															
% of children having visits	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.02	0.01	0.01	0.00	-0.01	-0.01
Per capita expenditure (NTD)	0.4	0.2	0.1	0.9	1.0	-0.1	1.3	0.9	0.4	1.3	1.0	0.2	-0.1	-0.3	0.1
Per capita expenditure of children using care (NTD)	1,758	3,160	-1402	10,267	8,522	1,745	10,612	10,064	548	5,128	8,016	-2,888	1,485	4,633	3,436
9 Iron deficiency anaemias															
% of children having visits	0.05	0.05	0.00	0.02	0.02	0.00	0.02	0.02	0.00	0.02	0.02	0.00	0.00	0.00	0.00
Per capita expenditure (NTD)	0.9	0.5	0.4	0.7	0.6	0.1	3.6	4.2	-0.5	0.3	0.2	0.1	0.3	0.0	-0.6
Per capita expenditure of children using care (NTD)	1,871	1,024	847	3,631	4,090	-459	19,428	22,854	-3,426	1,875	1,005	870	-23	-1,329	-4,296
10 Ill-defined symptoms concerning nutrition, metabolism, and development															
% of children having visits	0.50	0.64	-0.14	0.23	0.28	-0.05	0.29	0.33	-0.04	0.35	0.34	0.01	-0.15	-0.06	-0.05
Per capita expenditure (NTD)	18.7	18.7	-0.1	10.2	9.7	0.5	11.2	10.2	1.0	13.6	12.2	1.5	-1.5	-1.0	-0.5
Per capita expenditure of children using care (NTD)	3,737	2,943	794	4,359	3,520	839	3,830	3,136	694	3,941	3,530	411	383	428	283
11 Intestinal infectious diseases															
% of children having visits	2.75	3.02	-0.27	2.24	2.68	-0.44	2.61	3.15	-0.54	2.69	3.24	-0.55	0.28	0.11	0.01
Per capita expenditure (NTD)	14.8	16.0	-1.2	10.5	12.4	-1.9	12.4	14.4	-2.1	12.5	14.4	-1.8	0.7	-0.1	-0.2
Per capita expenditure of children using care (NTD)	540	530	10	470	465	5	474	458	16	467	444	22	-13	-17	-7
12 Tuberculosis															
% of children having visits	0.01	0.03	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	-0.01	-0.01	0.01	0.01
Per capita expenditure (NTD)	0.1	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0
Per capita expenditure of children using care (NTD)	1,087	682	406	1,737	1,325	412	756	1,172	-417	795	996	-201	606	612	-216

See footnotes at the bottom of the table.

Table 2. (cont.)

	Poverty (N=14617)			Near poverty (N=171650)			Middle income (N=384366)			High income (N=193893)			DD1‡	DD2‡	DD3‡
	Break time	School time	Diff.†	Break time	School time	Diff†	Break time	School time	Diff.†	Break time	School time	Diff†			
13 Upper respiratory infections															
% of children having visits	57.37	70.41	-13.04	51.64	63.32	-11.68	59.70	72.56	-12.86	59.64	72.15	-12.51	-0.53	0.83	-0.35
Per capita expenditure (NTD)	551.7	839.4	-287.7	476.6	712.5	-235.8	559.8	827.1	-267.3	594.8	857.7	-263.0	-24.8	27.1	-4.4
Per capita expenditure of children using care (NTD)	962	1,192	-231	923	1,125	-202	938	1,140	-202	997	1,189	-192	-39	-11	-11
14 Lower respiratory infections															
% of children having visits	3.78	6.51	-2.73	2.81	5.23	-2.42	3.38	6.16	-2.78	3.12	6.03	-2.91	0.18	0.49	0.13
Per capita expenditure (NTD)	28.8	53.8	-25.0	19.8	40.9	-21.1	24.0	41.4	-17.3	22.7	43.3	-20.6	-4.3	-0.5	3.3
Per capita expenditure of children using care (NTD)	761	826	-64	703	783	-80	711	672	40	726	719	7	-72	-87	33
15 Asthma															
% of children having visits	2.86	3.84	-0.98	2.61	3.61	-1.00	3.14	4.24	-1.10	3.92	5.26	-1.34	0.36	0.34	0.24
Per capita expenditure (NTD)	51.5	69.7	-18.2	41.0	53.6	-12.5	49.2	63.7	-14.5	84.5	103.7	-19.2	1.0	6.6	4.7
Per capita expenditure of children using care (NTD)	1,802	1,817	-15	1,569	1,482	87	1,568	1,503	65	2,158	1,973	185	-201	-98.	-121
16 Mental disorders															
% of children having visits	4.58	4.61	-0.03	2.05	2.23	-0.18	2.17	2.37	-0.20	2.60	2.77	-0.17	0.14	-0.01	-0.03
Per capita expenditure (NTD)	286.6	262.8	23.8	112.9	104.1	8.8	119.0	112.6	6.4	153.3	138.0	15.3	8.6	-6.5	-8.9
Per capita expenditure of children using care (NTD)	6,263	5,699	563	5,500	4,672	828	5,489	4,748	741	5,888	4,979	908	-345	-80	-167
17 Injury															
% of children having visits	12.00	12.47	-0.47	7.64	8.07	-0.43	8.55	8.97	-0.42	8.61	9.17	-0.56	0.09	0.13	0.14
Per capita expenditure (NTD)	183.8	182.1	1.7	101.2	104.7	-3.4	114.1	116.0	-1.9	111.4	115.8	-4.4	6.1	1.0	2.5
Per capita expenditure of children using care (NTD)	1,532	1,460	72	1,326	1,297	29	1,335	1,293	41	1,294	1,263	31	41	-2	11
18 Poisoning															
% of children having visits	0.00	0.00	0.00	0.00	0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00
Per capita expenditure (NTD)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	-0.1	0.0
Per capita expenditure of children using care (NTD)	0	0	0	571	942	-371	1,107	1,127	-19	2,229	1,771	457	-457	-828	-477

†Diff. is the figure of "break time" minus that of "school time".
‡DD1 is Diff for the "poverty" group minus Diff for the "high income" group. DD2 is Diff for the "low income" group minus Diff for the "high income" group. DD3 is Diff for the "middle income" group minus Diff for the "high income" group.
§Three children in the high income group had the following rare diseases: mucopolysaccharidosis, lipidoses, and ill-defined disorders of lipoid metabolism. Due to their extremely high NHI expenditures, the per capita expenditure of high-income children using care for this disease type was significantly higher than those for other economic groups.

Table 3. Factors associated with a child's probability of using ambulatory care, for the whole sample of children[†]

Explanatory variables	1 Thyroid disorders	2 Diabetes mellitus	3 Diseases of other endocrine glands	4 Protein-energy malnutrition	5 Nutritional deficiencies other than protein-energy malnutrition	6 Inherited disorders of metabolism	7 Obesity and other hyperalimentation	8 Immune disorders
Economic status (reference: middle income)								
Poverty	1.10	1.87 *	0.96	0.97	1.81	1.94 **	1.33	0.78
Low income	0.95	1.06	0.77 **	0.66 *	0.67	0.86 *	0.92	1.31
High income	1.15	1.06	1.50 **	0.81	0.83	1.06	1.23	1.46
Time type (reference: school time)								
Break	1.06	1.09	1.16 **	0.89	0.88	0.74 **	1.20	1.31
Low birth weight (reference: no)								
Yes	2.68 **	1.03	2.95 **	2.68 **	3.40 **	2.12 **	0.28	0.66
Interaction term (1)								
Break *poverty	0.94	1.32	0.93	1.12	1.13	1.31	0.91	2.28
Break *low income	1.11	1.00	1.04	1.39	0.84	1.07	0.84	0.57
Break *high income	0.88	1.04	1.08	1.06	1.01	1.08	0.79	1.46
Interaction term (2)								
Low birth weight *poverty	1.26	0.00	0.36	0.00	0.00	1.45	0.00	0.00
Number of ambulatory visits during the first week of life	1.15 **	1.04	1.01	1.00	1.09	1.10 *	1.08	1.21 **
Gender (reference: girl)								
Boy	0.49 **	1.00	0.20 **	0.84	1.42 **	1.23 **	1.12	1.05
NHI registration area (reference: north)								
Central	1.09	1.10	1.38 **	0.37 **	0.15 **	0.99	0.81 *	0.96
South	0.91	0.85	0.89 **	0.38 **	0.28 **	1.04	0.73 **	1.26
East	0.48 **	1.39	1.13	0.25 **	0.59	0.71 **	3.50 **	0.46
Urbanization level of NHI registration location (reference: large city)								
Small city or town	1.05	0.78 **	0.79 **	1.05	0.92	1.03	0.83 *	0.87
Rural area	0.93	0.72 **	0.63 **	1.00	0.80	0.95	0.62 **	1.10
Number of children	764526	764526	764526	764526	764526	764526	764526	764526
Number of observations	1529052	1529052	1529052	1529052	1529052	1529052	1529052	1529052
Model significance: Wald $\chi^2(16)$	216 **	48 **	2664 **	124 **	167 **	255 **	162 **	40 **

Table 3. (cont.)

Explanatory variables	9 Iron deficiency anemias	10 Ill-defined symptoms concerning nutrition, metabolism, and development	11 Intestinal infectious diseases	13 Upper respiratory infections	14 Lower respiratory infections	15 Asthma	16 Mental disorders	17 Injury
Economic status (reference: middle income)								
Poverty	2.68 *	2.02 **	0.97	0.91 **	1.11 **	0.89 *	2.29 **	1.52 **
Low income	0.78	0.83 **	0.84 **	0.54 **	0.83 **	0.83 **	0.92 **	0.87 **
High income	1.13	1.04	1.05 **	0.98 *	1.03 *	1.20 **	1.07 **	1.03 **
Time type (reference: school time)								
Break	1.03	0.90 **	0.82 **	0.43 **	0.51 **	0.69 **	0.90 **	0.95 **
Low birth weight (reference: no)								
Yes	3.75 **	3.92 **	0.96	1.36 **	1.30 **	1.67 **	4.51 **	0.97
Interaction term (1)								
Break *poverty	0.97	0.87	1.11	1.01	1.06	1.01	1.10	1.01
Break *low income	1.31	0.94	1.01	1.13 **	0.99	0.98	1.01	0.99
Break *high income	0.82	1.12	1.00	1.02 *	0.94 **	1.00	1.03	0.98
Interaction term (2)								
Low birth weight *poverty	0.00	0.97	1.34	1.34	1.31	1.61	0.92	1.07
Number of ambulatory visits during the first week of life	1.16	1.11 **	1.06 **	1.13 **	1.05 **	1.08 **	1.13 **	1.05 **
Gender (reference: girl)								
Boy	0.91	0.93 **	1.11 **	1.03 **	1.03 **	1.68 **	2.86 **	1.44 **
NHI registration area (reference: north)								
Central	2.60 **	1.17 **	1.14 **	1.22 **	1.37 **	0.68 **	0.74 **	1.24 **
South	0.74	1.00	1.44 **	1.16 **	1.17 **	0.67 **	0.83 **	1.06 **
East	2.45 **	0.99	1.06	0.77 **	0.82 **	0.80 **	0.75 **	1.09 **
Urbanization level of NHI registration location (reference: large city)								
Small city or town	0.98	0.95	0.87 **	0.93 **	1.07 **	1.04 **	0.81 **	0.96 **
Rural area	0.91	0.77 **	0.78 **	0.83 **	1.08 **	0.95 **	0.67 **	0.88 **
Number of children	764526	764526	764526	764526	764526	764526	764526	764526
Number of observations	1529052	1529052	1529052	1529052	1529052	1529052	1529052	1529052
Model significance: Wald $\chi^2(16)$	110 **	437 **	1759 **	42380 **	8236 **	6294 **	8705 **	4862 **

†Adjusted odds ratios estimated by the random-effects logit regression models are shown. Two disease types, tuberculosis and poisoning, had zero incidence for at least one economic group, and they were excluded from this analysis due to collinearity problems.
*p<0.05, **p<0.01

The adjusted RR's of ambulatory care expenses of children using care indicate that children in poverty did not have a higher level for endocrine and metabolic disorder, protein-energy malnutrition, nutritional deficiencies, and mental disorders, suggesting that care intensity regarding these diseases was not higher for children living in poverty (Table 4). Care intensity regarding infections and injury was modestly higher for children living in poverty (see the second page of Table 4). Adjusted RR's with regard to interaction terms, combining time of year and economic status, suggest that children living in poverty had a worse condition than children with low- or middle-income in terms of care intensity for iron deficiency anaemias (RR=1.88); for some reason, children with high income did not have a better condition than poor children in this regard (Table 4). Low birth weight was substantially associated with a higher ambulatory care expense among children using care for the following diseases: nutritional deficiencies other than protein-energy malnutrition (RR=2.86), ill-defined symptoms concerning nutrition, metabolism, and development (RR=1.39), lower respiratory infections (RR=1.26), and mental disorders (RR=1.73).

DISCUSSION

As the children's caregivers may have little knowledge on nutritionally-related disease expression, we expect that the proportion of children using health care as a result of nutritionally-related disorders and diseases (NRD) was under-estimated. Physicians might also have inadequate knowledge with regard to nutritionally-related disease expression, as this study found that a substantial proportion of ambulatory visits for treating problems related to nutrition and metabolism had "ill-defined symptoms concerning nutrition, metabolism and development" as a diagnosis. Physicians' lack of knowledge in this area might also contribute to the underestimation of these disease conditions.

Based on these potentially underestimated figures, we found that children living in poverty were significantly more likely to have ambulatory visits linked with diabetes, inherited disorders of metabolism, iron deficiency anemias, ill-defined symptoms concerning nutrition, metabolism and development, and mental disorders. As children living in poverty tend to have substantially higher food insecurity, these findings suggest that these aforementioned diseases are closely associated with food insecurity. Further research is necessary to clarify whether and how food insecurity contributes to incidence of these diseases, so as to provide concrete information with respect to social and health policies for the reduction of harmful effects of food insecurity on child health.

As expected, low birth weight was linked to many of these selected diseases, consistent with the theory that maternal nutritional status during pregnancy is an important factor of a child's later health.[18] Unexpectedly, we did not find that children with care linked to low birth weight had a larger likelihood of using ambulatory care for diabetes. Children with a birth weight less than 2500 g or no less than 4000 g are more likely to have diabetes than those with a birth weight between 3000 g and 3499 g.[19] The reason why low birth weight cases in our study did not have a large likelihood of having diabetes might be that the other children in our sample (the reference group) included some children with a birth weight <2500 g and some with a birth weight ≥4000 g, and inclusion of these children in the reference group resulted in an insignificant difference between the two groups categorized by medical care use associated with low birth weight.

Food insecurity-related infectious disease is well-recognized,[20] and is seen in our cohort of Taiwanese children for upper and lower respiratory tract infections, but not for intestinal infectious disease (where it may be under- estimated because families may deal with the situation outside the NHI system). It is intriguing that several child disease entities were found to be predictable on the basis of food insecurity (low birth weight or poverty) which are not currently or generally recognized as such. These include insulin-dependent diabetes (which will be the majority of the children attending ambulatory care for diabetes), inherited disorders of metabolism (where that may have, in some cases, preceded the evidence of food insecurity), mental disorders (although the link between diet and neurobehavioral disorders is becoming clearer[21]) and injury (where the interaction with nutritional status merits more attention since even obesity increases accident proneness[22,23]). This underscores the potential failure to diagnose and manage NRD in the present health care systems.

On the other hand, thyroid disorders were predictable more often than expected in a country with good sources of iodine in the diet (fish, seaweed and iodised salt), so that even where NRD are understood, namely iodine deficiency disorders, they may be under-diagnosed, too. More work is required to evaluate this possibility in the Taiwanese population. It is also possible that some of the food insecurity related to thyroid disorders are auto-immune: the increase risk of 'immune disorder' shows in its own right.

One of the most disquieting findings in this study is the increased risk of mental health disorders where there is a background of food insecurity. Since this also reflects maternal nutrition with its consequences for birth weight, the inter-generational implications have extensive policy ramifications for maternal-child health.

Although the publicly-funded lunch program was expected to help in reducing the children's food insecurity problem during the semester, this study failed to find any significant effect on alleviating harmful health effects of food insecurity for poor children. The descriptive difference-in-differences analysis tended to suggest an effect of the semester-dependent publicly-funded lunch program on reducing disparity in disease severity levels (per capital expenditures) for thyroid disorders, diseases of other endocrine glands, and protein-energy malnutrition between poor and non-poor children among care users. However, the corresponding multivariate analysis, while generating relatively large coefficients, failed to yield statistically significant evidence. This suggests that a more intensive food program or other program approaches might be required to help poor children overcome food insecurity and its related health outcomes. In Taiwan, there is no intensive publicly-funded food program targeted at poor families.

Table 4. Factors associated with the expense on ambulatory care, for children using care[†]

Explanatory variables	1 Thyroid disorders	2 Diabetes mellitus	3 Diseases of other endocrine glands	4 Protein-energy malnutrition	5 Nutritional deficiencies other than protein-energy malnutrition	6 Inherited disorders of metabolism	7 Obesity and other hyperalimentation	8 Immune disorders
Economic status (reference: middle income)								
Poverty	0.54	0.91	0.64	0.79	1.42	0.84	0.78	1.42
Low income	0.91	1.25	0.94	0.93	1.09	1.06	1.00	1.14
High income	0.99	1.15	1.00	0.97	1.04	1.01	0.99	1.39
Time type (reference: school time)								
Break	1.21 **	1.19 **	1.14 *	1.04	1.22	1.06	1.15	1.22
Low birth weight (reference: no)								
Yes	1.25	2.36	1.31	0.96	2.86 **	1.19	0.83	0.50
Interaction term (1)								
Break *poverty	2.61	1.02	1.54	1.95	0.55	1.11	0.93	0.81
Break *low income	1.08	0.99	1.00	0.94	0.94	0.98	1.15	0.81
Break *high income	1.12	1.03	1.09	0.84	1.19	1.12	0.95	0.56
Interaction term (2)								
Low birth weight *poverty	1.55	-	0.28 **	-	-	0.73	-	-
Number of ambulatory visits during the first week of life	0.90	1.02	1.15	1.01	1.63 *	1.06	1.12	2.66
Gender (reference: girl)								
Boy	0.97	0.84	1.19 **	0.88	1.01	1.05	0.86 *	1.43
NHI registration area (reference: north)								
Central	1.20 *	0.94	1.51 **	0.59 **	0.99	1.11 *	0.99	3.00 **
South	1.09	1.06	1.57 **	0.52 **	0.87	1.07	1.13	2.29 **
East	1.21	0.98	1.03	3.25	0.95	1.03	1.07	2.41 **
Urbanization level of NHI registration location (reference: large city)								
Small city or town	0.93	1.19	0.96	1.05	1.20	0.97	1.08	1.20
Rural area	0.80 *	0.82	0.86 *	0.75 *	0.80	0.84 **	0.97	0.79
Number of children	1041	560	4148	461	294	3324	826	156
Number of observations	1369	881	5168	518	368	3654	890	193
Model significance	Wald $\chi^2(15)$ =47**	Wald $\chi^2(15)$ =49**	Wald $\chi^2(15)$ =7362**	Wald $\chi^2(15)$ =85**	Wald $\chi^2(15)$ =65*	Wald $\chi^2(16)$ =34**	Wald $\chi^2(15)$ =20	Wald $\chi^2(12)$ =45**

Table 4. (cont.)

Explanatory variables	9 Iron deficiency anaemias	10 Ill-defined symptoms concerning nutrition, metabolism, and development	11 Intestinal infectious diseases	13 Upper respiratory infections	14 Lower respiratory infections	15 Asthma	16 Mental disorders	17 Injury
Economic status (reference: middle income)								
Poverty	0.83	0.88	1.14 **	1.05 **	1.13 **	1.07	1.06	1.06 **
Low income	0.84	0.99	1.02	0.97 **	1.02 **	0.99	0.98	1.00
High income	0.73	1.04	1.02	1.04 **	1.03 **	1.04 **	1.03	0.99
Time type (reference: school time)								
Break	0.92	1.07	1.05 **	0.82 **	1.02 **	1.01	1.06 **	1.01
Low birth weight (reference: no)								
Yes	0.99	1.39 *	0.95	1.16 **	1.26 **	1.11 **	1.73 **	1.11 **
Interaction term (1)								
Break *poverty	1.88 *	1.07	0.99	0.99	0.95	0.97	1.00	1.03
Break *low income	0.98	0.95	1.00	1.00	0.97 *	1.01	1.01	1.00
Break *high income	1.77 *	0.99	1.02	1.02 **	1.02	1.00	1.02	0.98
Interaction term (2)								
Low birth weight *poverty	-	0.72	1.28	1.20 **	1.28	1.03	0.79	1.16
Number of ambulatory visits during the first week of life	1.08	0.98	1.00	1.02 **	1.03 **	1.01	1.05	1.01
Gender (reference: girl)								
Boy	1.12	0.95	1.03 **	1.05 **	1.04 **	1.06 **	1.13 **	1.08 **
NHI registration area (reference: north)								
Central	1.75 **	1.03	1.14 **	1.17 **	1.03 **	1.01	0.71 **	1.07 **
South	1.19	1.07	1.13 **	1.07 **	1.06 **	1.07 **	0.76 **	0.96 **
East	1.60	0.77 **	1.06 **	0.93 **	1.15 **	1.28 **	0.85 **	0.89 **
Urbanization level of NHI registration location (reference: large city)								
Small city or town	0.79	0.96	0.92 **	0.92 **	0.94 **	0.94 **	1.00	0.99
Rural area	0.88	0.85 **	0.91 **	0.90 **	0.93 **	0.90 **	0.90 **	0.99
Number of children	237	4104	39401	612766	61032	43964	25338	119251
Number of observations	287	4751	42898	979936	69729	57805	36557	132333
Model significance	Wald $\chi^2(15)$ =39**	Wald $\chi^2(16)$ =34**	Wald $\chi^2(16)$ =729**	Wald $\chi^2(16)$ =28556**	Wald $\chi^2(16)$ =323**	Wald $\chi^2(16)$ =248**	Wald $\chi^2(16)$ =763**	Wald $\chi^2(16)$ =693**

† Coefficients estimated by the random-effects linear regression models were transformed by the exponential function to show the adjusted relative ratios of expense. Two disease types, tuberculosis and poisoning, had zero incidence for at least one economic group, and they were excluded from this analysis due to collinearity problems.
*p<0.05, **p<0.01

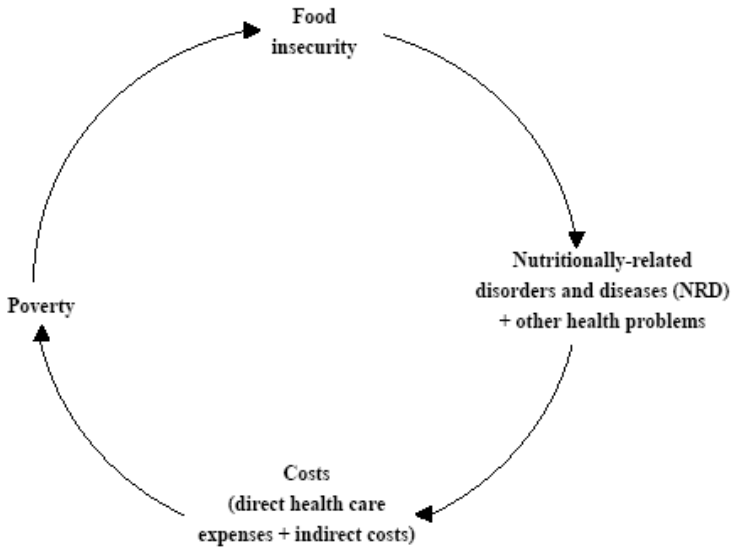

Figure 2. The vicious cycle of poverty and food insecurity

One reason why effects of the school lunch program were not detected in this study is that the time-frames over which nutritional factors operate may be short to medium and long-term and depend on which nutrients are the most critical in the setting under enquiry. An example would be iron deficiency anaemia, which was observed more commonly in both low and high family income children: it is known that iron deficiency affects cognition early and persistently in life. By contrast, vitamin C is a water soluble vitamin whose deficiency can be rapidly corrected with good food sources, in a school lunch program.

Some of the inability to recognize a lunch program effect may be attributable to other factors, different between break and semester, which mask it. In this event, the socio-cultural context of lunch programs may also be important. For example, it is known, anecdotally, that poor children may take their food home for the family and not benefit from it themselves.

Given that this study discovered disparity in child health problems that are potentially associated with food insecurity, the government should make more efforts to investigate food insecurity problems among women in the reproductive years and poor children, and formulate social and health policies to help them accordingly.

Finally, it should be noted that poverty and food insecurity could form a vicious cycle (Figure 2). While poverty brings about food insecurity, food insecurity can subsequently cause further wealth deprivation through disease burdens, including direct health care expenditures and indirect costs linked to productivity loss. Such a cycle could lead to immobility in social class for poor children. This highlights a profound linkage of food insecurity with social injustice. Ensuring food security for children is thus one of a government's most important responsibilities.

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AUTHOR DISCLOSURES

The authors claim no conflict of interests.

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Original Article

Imputed food insecurity as a predictor of disease and mental health in Taiwanese elementary school children

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食物來源不穩定性在臺灣學童兒童疾病與精神健康方面的預測因子角色

本研究檢視食物來源不穩定性與台灣兒童十八類疾病相關門診服務利用的關聯性；這些疾病類型有關內分泌和新陳代謝失調、營養、免疫、感染、氣喘、精神健康、事故傷害、中毒。我們使用 764,526 位小學兒童的全民健保長期追蹤資料，並採用健保資料中之相關訊息來建構三種食物來源不穩定性的替代測量指標：低出生體重狀態、經濟狀況（貧窮相對於非貧窮）以及時間點（暑假時間相對於學期時間）。我們比較低出生體重之兒童和其他兒童的前述十八類疾病相關門診服務利用，也比較家境處貧窮線以下和以上之兒童的相關醫療服務利用。此研究利用「差異中之差異」分析法檢驗公共午餐計畫改善食物來源不穩定性對貧窮孩童健康傷害之能力。研究發現家境處貧窮線以下之兒童明顯使用較多有關下述疾病之門診服務：糖尿病、遺傳性代謝失調、缺鐵性貧血，以及營養、新陳代謝、發育相關之不明確徵候，還有精神狀況失調。低出生體重兒童相關醫療服務的利用除了前述疾病外，也較可能使用有關其他內分泌異常與營養不足的服務。本研究並未發現學期中提供之學校營養午餐計畫有減輕食物來源不穩定性對貧窮孩童之健康傷害，顯示可能需要更密集的食物計畫或其他方案來幫助貧窮孩童克服食物來源不穩定性和相關之健康後果。

關鍵字：食物來源不穩定性、疾病、精神健康狀況、醫療花費、兒童