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IMPROPER PAYMENTS TO WIC VENDORS: 2005–2008

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United States Department of Agriculture **Food and Nutrition Service**

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CHAPTER 1

INTRODUCTION

BACKGROUND

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) of the U.S. Department of Agriculture, Food and Nutrition Service (FNS) was designed to respond to the health and nutritional needs of low-income pregnant, breast-feeding, and postpartum women, infants, and children up to age 5. WIC provides participants with vouchers or Electronic Benefit Transfer cards that can be used at authorized vendors to obtain a monthly package of supplemental foods. It also provides nutrition education and health care and social service referrals.

About every 7 years, FNS performs a nationally representative study (called a bookend study[1]) to examine the extent of error and abuse among food vendors authorized to accept WIC vouchers. The last bookend study was the 2005 WIC Vendor Management Study, which used fiscal year (FY) 2005 expenditure data to derive an estimate for 2004. Between bookend studies, there is a need to derive annual estimates of the level of improper payments for compliance with the Improper Payments Information Act of 2002. FNS therefore contracted with ICF Macro to develop methodology for "aging" the 2005 bookend estimates of improper payments based on empirical surveys of samples of WIC vendors across the nation. The purpose of the subsequent annual studies was to provide annual updates to the bookend studies using the developed aging methodology.

Improper payments are comprised of two components: overcharge and undercharge. The term "overcharge," as used in these WIC studies, refers to a vendor charging the WIC customer more than a non-WIC customer would pay for the same item. It does not mean charging higher prices than other vendors. On the other hand, an "undercharge" refers to a vendor charging the WIC customer less than a non-WIC customer. Also, undercharge does not mean a vendor charging less than other vendors.

PURPOSE OF THE IMPROPER PAYMENTS STUDIES

The specific objective for developing the aging methodology is to derive annual national estimates of the numbers of vendors who over- or undercharged and the dollar amounts of over- and undercharges. The following main research question was examined for each annual study:

- What are the national estimates of dollars constituted by vendor over- and undercharges to the WIC program (erroneous or improper payments)?

[1] The term "2005 bookend" derives from the fact that since these studies occur about every 7 years, they frame a period during which no observations are made.

CHAPTER 2

METHOD

INTRODUCTION

Separate methodologies were applied in deriving improper payments in the bookend studies (1991, 1998, and 2005) and the annual estimates for the intervening years between bookend studies. This document, first explains the aging methodology; it then presents the estimates created for 2005, 2006, 2007 and 2008.

METHODLOGY OF THE BOOKEND STUDY (2004)

The bookend studies, conducted in 7-year cycles, collect empirical data from undercover shoppers who attempt to buy WIC foods in a nationally representative multi-stage, statistical sample of WIC vendors. In the 2005 study, the lower 48 States and the Indian Tribal Organizations (ITOs) (as WIC State agencies) comprised the State agency sampling frame. In deriving the sample, first, a representative sample of 100 primary sampling units (PSU) was randomly selected. Using geo-coded county information on the retail vendor population, and the parameters of at least 80 retail vendors per PSU with each constituted by a single or groups of contiguous counties within a State, a sampling frame of 365 PSUs was generated. From this, the random sample of 100 PSUs was drawn, covering 41 States and the District of Columbia. The number of PSUs within a state was directly related to the size of the State's vendor population – hence, sampling with probability proportional to size. Whereas most sample states had one or two PSUs, large States such as New York, California, Texas, Florida, and Georgia had multiple PSUs. Los Angeles County and two New York City Boroughs each had multiple PSUs. Next, about 16 WIC vendors were selected from each of the 100 PSUs, resulting in a total vendor sample size of 1,610. In anticipation of possible difficulties in contacting some sample vendors (such as vendors no longer authorized or in business, etc.), a reserve or backup of 403 vendors was held bringing the total selected vendors to 2,013.

WIC vendors are generally food stores or pharmacies (for infant formula). Before the 2005 bookend study was initiated, however, a new type of WIC vendor had appeared. Known as WIC-only vendors, these businesses catered to WIC recipients, selling only WIC authorized foods. A concern was that these vendors charged the maximum legal price for WIC products, rather than prices set by a competitive marketplace.

Therefore, the sample was stratified into three strata to facilitate oversampling of WIC-only vendors: (1) States with few or no WIC-only vendors, which included vendors from all the 41 States and the District of Columbia; (2) Los Angeles County which contained 38% of the nations WIC-only vendors; and (3) all vendors in California (except Los Angeles County), Florida and Texas. The stratification resulted in 70 PSUs in Stratum 1, 7 in Stratum 2, and 23 in Stratum 3.

Types of Undercover Buys

In order to capture the targeted variety of consumer and vendor behaviors that impact improper payments, three types of undercover buys were conducted at each vendor: safe, partial, and substitution buys.

Safe Buy: A safe buy is the undercover attempt by field staff to purchase all food items listed on the WIC voucher in the quantities and types listed. A safe buy represents the typical form of WIC food transaction, and therefore one in which both inadvertent and deliberate errors are likely to be committed by the WIC vendor at relatively high frequencies. Thus, it represents a major source of improper payments.

Partial Buy: A partial buy is an attempt by an undercover shopper to purchase some but not all of the items prescribed on the WIC voucher.

Substitution Buy: Every WIC voucher has a set of prescribed foods for the WIC client selected from the total inventory of categories of WIC approved or authorized foods. In some cases, either the participant or vendor may initiate a substitution of some of the items on the voucher for various reasons, such as the desire by the WIC participant to purchase some other brand of a similar food item that may, nonetheless, not be in the approved list of WIC foods, or a totally different food type, or a non-food item altogether such as cigarettes. It goes without saying that in some cases, a vendor may also initiate a substitution perhaps because a particular approved WIC product is not available and the vendor may offer the WIC participant the opportunity to substitute a non-approved item for the product that is not available. As such, there are two categories of substitutions, based on the nature of the food items or commodities:

Minor Substitution: A minor substitution occurs when a vendor allows the buyer to use a WIC voucher to substitute an item that is of the same category as the WIC-approved food (e.g., cereal, juice) but is not on the WIC approved list.

Major Substitution: A major substitution is when a vendor allows a buyer to use the WIC voucher to purchase an item that does not fall within one of the WIC food categories. For instance, the buyer is allowed to purchase soda instead of juice that is prescribed on the WIC voucher.

METHODLOGY OF THE ANNUAL IMPROPER PAYMENT ESTIMATES (2005-2008)

Approach

A methodology for updating the statistics generated by the 2005 WIC Vendor Management Study (the 2005 Bookend study) was developed and used in order to address the research questions. The methodology required consistency with the definitions applied in that study. Two

separate methodological approaches were developed: one for the estimation of overcharges and the other for the estimation of undercharges.

Overcharges are estimated using The Integrity Profile (TIP)[2] data system (see Appendix B). TIP is a roster of all WIC vendors authorized by State agencies. It contains information on WIC vendor characteristics and annual redemption[3] dollars, as well as monitoring, investigations, and audit activities, and their outcomes. Because TIP data are not a random sample of all vendors – investigators target vendors that are most likely to be error prone – using TIP data without adjustment would result in overestimates of erroneous activities. Therefore, a post-stratification weighting algorithm, known as data raking, was applied to the TIP data. The weights generated through the raking algorithm allow the TIP data to be adjusted to more reasonably reflect the activities of all WIC vendors.

Estimating undercharges (charging less than the shelf price for WIC-prescribed food items) required a different approach because TIP does not collect information on vendor undercharging. While undercharging is an error that is not in the vendor's best interests, it is not a sanctionable offense; it is, however, an improper payment. Therefore, undercharge estimates were based on the data collected in the 2005 bookend study, with adjustments for changes in redemption dollars and vendor characteristics. Using the results of a logistic regression conducted with the 2005 bookend data, the probability of undercharging was estimated for every vendor in the 2005 TIP system. Similarly, using the results of a linear regression conducted with the 2005 bookend data, the dollar value of annual undercharges (assuming undercharge occurred) was calculated for each vendor in the 2005 TIP system. For each vendor, the probability of undercharging was then multiplied by the annual value of undercharges to determine the expected value of undercharges (see Appendix B). All of the undercharge estimates presented in this report are based on this expected value.[4]

VALIDATION

The methodology developed to estimate the 2005 improper payments provided an outcome similar to the 2005 bookend study; because results were virtually the same. It is important to recognize that it utilized a combination of new and old data on violation propensity. In subsequent use of this methodology, each year overcharges are estimated based on TIP data and therefore approximate the current propensity to overcharge (based on changes in the outcomes of compliance buys, composition of the WIC vendor community, and the amount of redemption

[2] State WIC agencies are required to conduct compliance buys or inventory audits on 5 percent of WIC vendors each year, and report the results to FNS. FNS compiles these results into TIP.

[3] Throughout this report, the term "redemption" and similar terminology such as "redemption dollars" is used to describe outlays for WIC food purchases, i.e. WIC food costs after rebates have reduced the net cost to the government. Since food outlays are not available by individual WIC vendors, they have to be estimated. This estimate was derived by dividing state level outlay figures by the sum of all redemptions within a state as provided by TIP. All vendors in the state were included in this calculation. This state-level ratio was applied to redemptions reported in TIP for each retailer.

[4] Estimates of the number of vendors undercharging, as opposed to the dollar value of undercharges, are based on the probabilities for undercharging predicted from the 2005 bookend study.

dollars). On the other hand, undercharges carry the 2005 bookend study error rates forward until the next bookend study, and change only as the store population and redemption dollars change.

The overcharge and undercharge estimations methodologies developed using the FY 2005 data, were applied in the subsequent estimates of overcharge and undercharge for FY 2006, FY 2007, and FY 2008. Significance testing was not done because the focus was on whether any large differences occurred rather than on the detection of small differences that might be significant. It should be noted that all the estimates indicate that over- and undercharging represent a relatively small proportion of redemptions and thus pose a small risk to program integrity.

CHAPTER 3

RESULTS

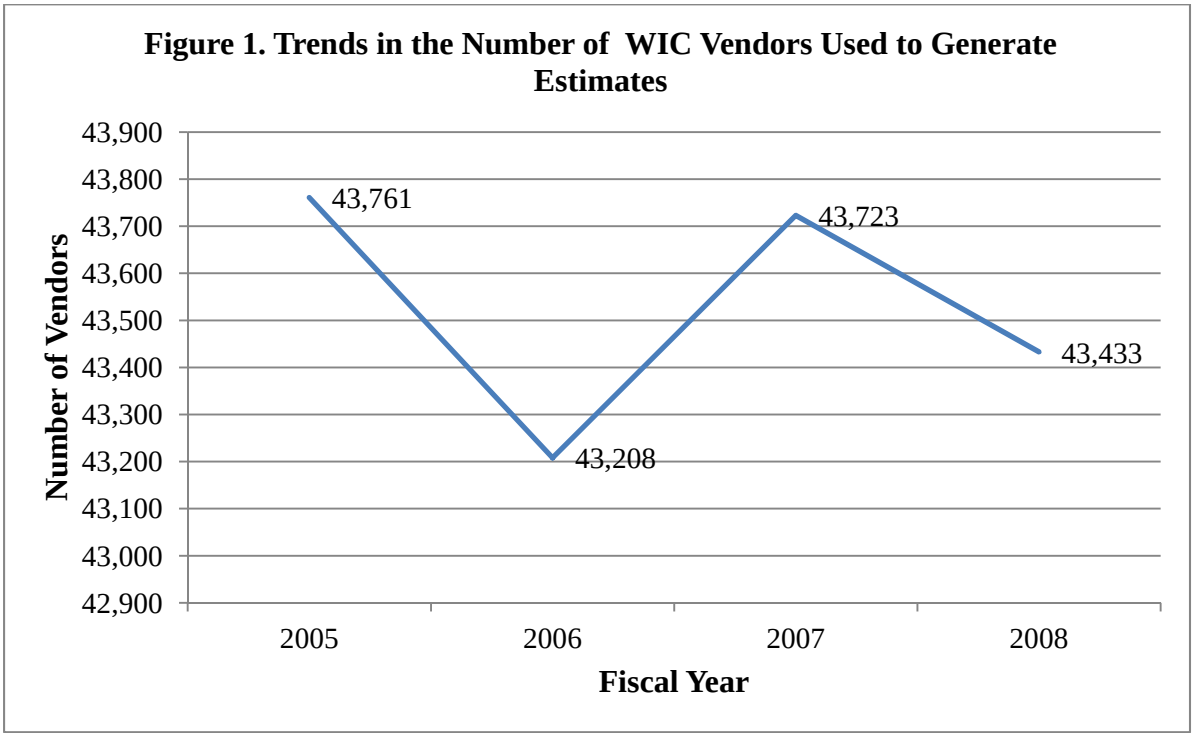
INTRODUCTION

This chapter presents annual estimates of the number of WIC vendors nationwide, the amount of WIC food outlays expended annually, and the total WIC improper payments consisting of vendor overcharges and undercharges.

TRENDS IN THE NUMBER OF WIC VENDORS

From FY 2005 to FY 2008, the number of WIC vendors used to generate estimates remained between 43,208 and 43,761 stores (see Figure 1). This number represents vendors within 45 States and the District of Columbia. Five States (Alaska, Hawaii, Mississippi, North Dakota, and Vermont) were excluded from the estimate to maintain consistency with the estimates generated for the 2005 bookend study.

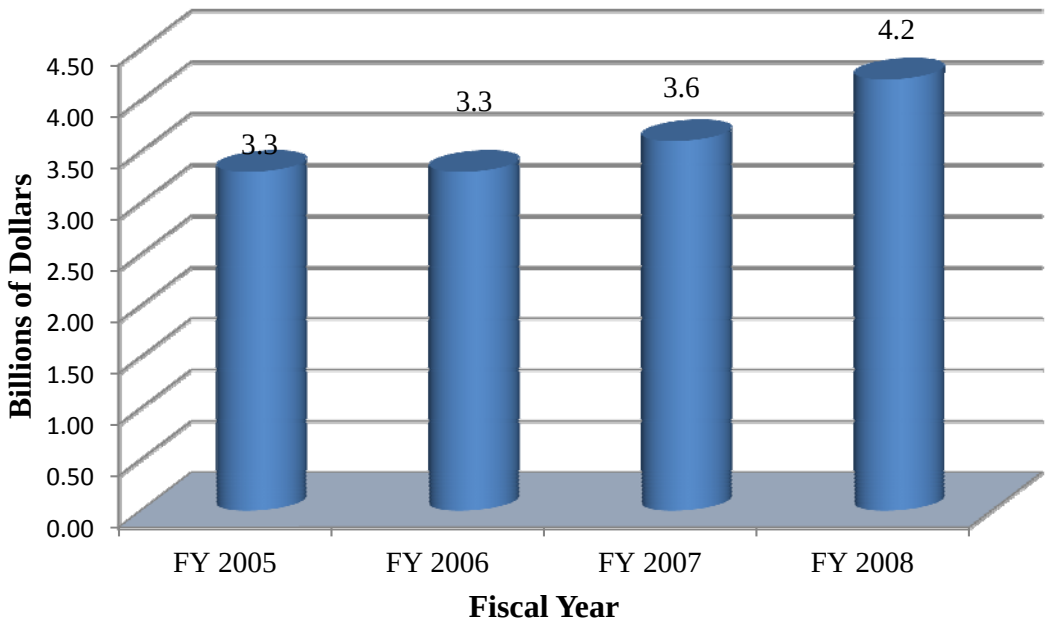
Figure 1. Trends in the Number of WIC Vendors Used to Generate Estimates



TRENDS IN WIC ANNUAL FOOD OUTLAYS

The 2005 Bookend study found the WIC annual food outlays to be $3.6 billion. In FY 2005 and FY 2006, estimated total WIC food outlays were found to be slightly lower in this study (see Figure 2). From FY 2006 to FY 2008, WIC food outlays have increased steadily from 3.3 billion dollars to 4.2 billion dollars with the largest increase occurring between FY 2007 and FY 2008. This increase was especially notable between FY 2007 and FY 2008, where the increase was about $600 million dollars. The food outlays provided in Figure 2 exclude redemptions of vendors from the states and territories cited in the previous paragraph, and attempt to eliminate formula rebate redemptions.

Figure 2. WIC Annual Food Outlays: 2004 - 2008 (in Billions of Dollars)



OVERCHARGES, UNDERCHARGES, AND TOTAL IMPROPER PAYMENTS

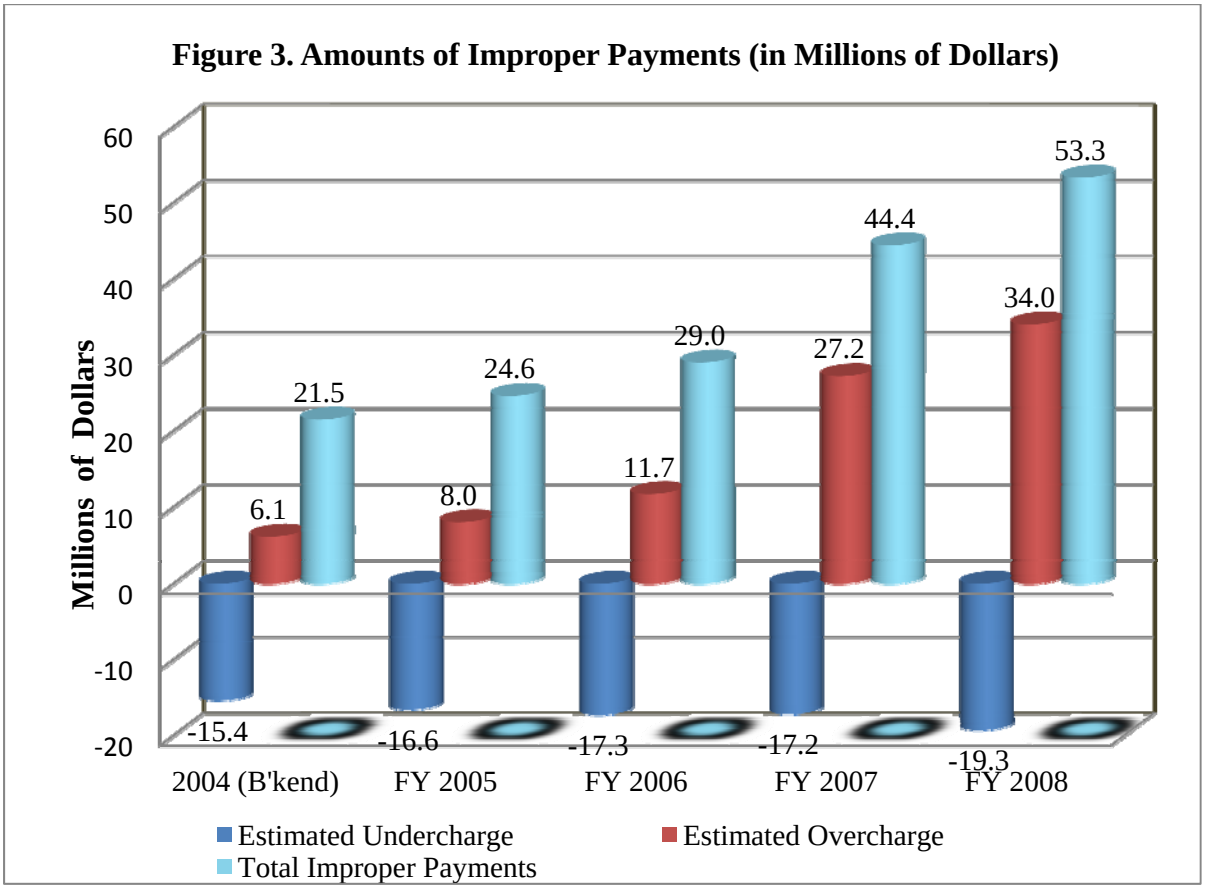
Total improper payments for participating States in FY 2008 were estimated at $53.3 million (see Table 1; Figure 3). This represents 1.3 percent of total WIC food outlays of $4.2 billion. Table 1 provides information on percent of total WIC food outlays for 2005 through 2008 represented by total improper payments. Estimated overcharges increased more dramatically than estimated undercharges between FY 2005 to FY 2008, from 8 million dollars in FY 2005 to 34 million dollars in FY 2008 compared to an increase from 16.6 million to 19.3 million in undercharges.

Table 1. Comparison of Total WIC Food Outlays and Total Improper Payments

Fiscal Year	WIC Food Outlays (in billions)	Total Overcharge (in millions)	Total Undercharge (in millions)	Total Improper Payments (in millions)	% of Total WIC Food Outlays
2005	$3.3	$8.0	$16.6	$24.6	0.74%
2006	$3.3	$11.7	$17.3	$29.0	0.88%
2007	$3.6	$27.2	$17.2	$44.4	1.2%
2008	$4.2	$34.0	$19.3	$53.3	1.3%

The apparent diversion in the trends in 2007 – with overcharges appearing to increase while undercharges remain the same – might well be a reflection of the differences in the sensitivities of the two methodologies applied in estimating the two rates (see Figure 3). The raking technique (using fresh TIP data each year) shows a higher sensitivity in capturing changes than the regression technique applied in estimating undercharges.

Figure 3. Amounts of Improper Payments (in Millions of Dollars)



CHAPTER 4

CONCLUSION

This report summarizes the methodology and results of four annual estimates of improper payment in the WIC Program between FY 2005 and FY 2008. The details of the yearly estimates of WIC vendor improper payment estimates and information on the methodologies used for deriving improper payments in both the bookend and in the annual estimates, and trends in number of vendors, annual food outlays, and improper payments are presented in the attachments.

- The bookend studies, conducted in 7-year cycles, collect empirical data from undercover shoppers who attempt to buy WIC foods in a nationally representative multi-stage, statistical sample of vendors authorized to accept WIC food vouchers.

- The annual improper payment estimates aim to establish interim national estimates of WIC dollars constituted by vendor over and undercharges based entirely on the TIP data, which focuses on vendors believed to be error-prone, and changes in the distribution of vendor categories and redemption amounts. The annual TIP estimates are adjusted through post-stratification weighting to better represent all vendors and redemptions.

- The methodology for calculating interim estimates of improper payments at WIC vendors produced very similar results to the bookend study when calculated for the same time period (2005). This similarity suggests – but does not prove – that the method is valid. However, separate methodologies are used for deriving improper payments in the bookend and improper payment studies.

- The number of WIC vendors remained between 43,208 and 43,761 stores from FY 2005 to FY 2008 - a difference of 553 vendors. WIC funds dedicated to food expenses each year have fluctuated over the four-year period analyzed but appear to be on the rise. In FY 2004, the WIC food outlay was $3.6 billion, which declined to $3.3 billion in FY 2005 and FY 2006, and has since risen to $4.2 billion in FY 2008.

- The FY 2005 through FY 2008 annual estimates suggest an increasing trend in total improper payment rates due to a continued increase in overcharges. Another trend is that prior to FY 2007, undercharges exceeded overcharges; whereas beginning in FY 2007 overcharges have exceeded undercharges.

- Between FY 2005 and FY 2008, improper payments have remained at about 1 percent of food outlays.

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APPENDIX A: VENDOR CHARACTERISTICS

APPENDIX A

VENDOR CHARACTERISTICS

This appendix describes the characteristics of the vendors of the WIC Program described in the TIP data system and their associated redemption dollars for FY 2005-2009. Exhibit A1 provides number of investigated vendors, total vendors in our final dataset, and vendors in TIP system by Fiscal Year.

Exhibit A1. Number of Investigated Vendors, Vendors in Final Dataset, and Vendors in TIP system by Fiscal Year

Fiscal Year	Investigated Vendors	Vendors in Final Dataset	Vendors in TIP system
	#	#	#
2005	5,558	43,761	49,297
2006	4,548	43,208	48,764
2007	4,754	43,723	48,172
2008	6,646	43,433	47,736
2009	6,373	41,612	47,829

DERIVATION OF THE ANALYTIC DATASET

The 2005-2009 TIP system maintains records for approximately 48,000 authorized WIC vendors in the United States, its territories, and possessions (see Exhibit A1). Because this report seeks to confirm and update the results of the 2005 WIC Vendor Management Study (2005 Bookend study), it was necessary to limit the final analytic dataset to the vendors and locations considered in that study.

The 2005 Bookend study used a representative sample of WIC vendors with traditional retail delivery systems operating in the continental United States. As a result, the following classes of vendors were removed from the 2005 bookend sample frame:

- Direct distribution delivery systems—all vendors in Mississippi and a few in Illinois
- Home delivery systems—all vendors in Vermont and some areas of Ohio
- Military commissaries—located on military bases
- Pharmacies that provide only prescription infant formula and WIC-approved medical foods
- All vendors in Alaska, Hawaii, North Dakota, and U.S. territories
- All vendors authorized solely by independent tribal organizations

In order to replicate the population examined by the 2005 Bookend study, vendors in the groups listed above were removed from the analytic dataset. This is reflected in the approximately 5,000 fewer vendors in the final analytic datasets for FY 2005-2009 (see Exhibit A1).

Information from the Supplemental Nutrition Assistance Program (SNAP) from the Store Tracking and Redemption System (STARS) II database was used to add store characteristic information (i.e., store type and ownership), and Census 2000 data were used to add geographic information on the areas served by the vendor.

VENDOR TYPE

This study included the following TIP vendor categories: retailer, WIC-only, and WIC above-50-percent. STARS II data were matched to the authorized SNAP retailers and used to identify the business type and gross sales information of all WIC vendors. From the sales information, WIC vendors were classified as large (with sales more than $500,000) or small (with sales of $500,000 or less). Vendors that could not be matched were classified as stores with unknown sales.

For FY 2005-2009, large retailers constituted the majority (70.8-73.3 percent) of all WIC vendors[5], redeeming 77.8 to 86.9 percent of WIC benefits. Also, large retailers accounted for about half (43.4-50.1 percent) of investigated vendors and from 43.6 to 64.1 percent of all investigated retailers' redemption dollars. Conversely, small retailers comprised 22.2 to 23.3 percent of all WIC vendors and 41.8 to 46.8 percent of investigated vendors. Like small retailers, WIC-only and WIC above-50-percent vendors were also investigated at higher rates than their proportions of the vendor population.

[5] "All WIC vendors" represents all WIC vendors in the final dataset.

OWNERSHIP

As in determining vendor type, to categorize the ownership type of WIC retailers (i.e., private versus public), STARS II ownership data were matched to authorized SNAP retailers. Unmatched retailers were categorized as stores with unknown ownership. An ownership status was assigned if the unmatched store was part of a chain that could reliably be identified as private or public through the SNAP files.

For FY 2005 through 2009, sixty-seven to seventy percent of all WIC vendors were privately owned, yet privately owned vendors accounted for only 51 to 58 percent of all redemption dollars (see Exhibit A2). Privately owned vendors were also more frequently investigated (79-87 percent) than publicly owned vendors (11-16 percent).

Exhibit A2. Vendors by Store Ownership (TIP 2005-2009)

FY	Ownership Type	Investigated Vendors			All Vendors		
		#	%	% of Redemptions	#	%	% of Redemptions
2005	Private	4,440	79.9	55.9	30,241	69.1	52.5
	Public	766	13.2	18.8	11,952	27.3	35.0
2006	Private	3,597	79.1	49.6	28,990	67.1	51.0
	Public	587	12.9	14.9	12,042	27.9	36.6
2007	Private	3,824	80.4	61.4	29,313	67.0	53.0
	Public	768	16.2	26.1	13,138	30.1	38.4
2008	Private	5,636	84.8	70.0	29,242	67.3	52.7
	Private	792	11.9	20.4	12,747	29.4	38.7
2009	Public	5,572	87.4	78.6	28,985	69.7	58.3
	Private	724	11.4	19.2	11,887	28.6	40.1

URBANIZATION

WIC vendors were matched by ZIP Code to Census files, which provided information needed to calculate the level of urbanization within the ZIP Code. More than half (56.1-57.2 percent) of all WIC vendors and two-thirds (67.4-73.6 percent) of all investigated vendors were located in dense urban settings (areas with 90% or more in their zip code identified as living in an urbanized area) (see Exhibit A3).

Exhibit A3. Ninety Percent or more of Population in ZIP Code Identified as Living in Urbanized Area (TIP 2005-2009)

FY	Investigated Vendors			All Vendors		
	Number	Percent	Percent of All Redemption Dollars	Number	Percent	Percent of All Redemption Dollars
2005	3,793	67.4	74.0	24,542	56.1	67.2
2006	3,260	71.7	81.5	24,528	56.8	65.0
2007	3,324	69.9	77.0	25,018	57.2	65.8
2008	4,831	72.7	77.0	24,862	57.2	65.7
2009	4,688	73.6	77.3	23,811	57.2	65.6

PERCENTAGE IN POVERTY

WIC vendors were matched by ZIP Code to Census files, and the percentage of households under the poverty level within the ZIP Code was calculated. Approximately 10 percent of all WIC vendors and 19 percent of investigated vendors were located in areas where 30 percent or more of households live in poverty (see Exhibit A4). Thus, vendors in these areas were investigated to a greater extent, proportionally, than other vendors. The redemption values reflected this result (see Exhibit A4). This means that in terms of both vendors and redemption dollars, the lowest poverty areas (20 percent or less) were investigated to a lesser extent than found in the vendor population. The percentages of both vendors and redemption dollars in the low poverty areas were about the same.

Exhibit A4. Vendors by Poverty Level (TIP 2005-2009)

FY	Percent of Households Below the Poverty Level in ZIP Code	Investigated Vendors			All Vendors		
		Number	%	% of All Redemption Dollars	Number	%	% of All Redemption Dollars
2005	20 percent or less	3,209	57.7	61.8	31,910	72.9	71.4
	More than 20 percent but less than 30 percent	1,281	23.1	23.4	7,419	17.0	19.4
	30 percent or more	1,068	19.2	14.8	4,432	10.1	9.2
	Total	5,558	100.0	100	43,761	100.0	100
2006	20 percent or less	2,637	58.0	61.4	31,715	73.4	70.5
	More than 20 percent but less than 30 percent	990	21.8	24.5	7,200	16.7	20.6
	30 percent or more	921	20.3	14.1	4,293	9.9	8.9

	Total	4,548	100	100	43,208	100	100
2007	**20 percent or less**	2,870	62.5	67.0	32,476	74.3	73.7
	More than 20 percent but less than 30 percent	1,006	21.2	23.4	7,115	16.3	18.0
	30 percent or more	778	16.4	9.6	4,132	9.4	8.3
	Total	4,754	100	100	43,723	100	100
2008	**20 percent or less**	3,811	57.3	62.7	32,273	74.3	73.7
	More than 20 percent but less than 30 percent	1,493	22.5	23.3	7,048	16.2	18.1
	30 percent or more	1,342	20.2	14	4,112	9.5	8.2
	Total	6,646	100	100	43,433	100	100
2009	**20 percent or less**	3,532	55.4	62.2	31,012	74.5	75.5
	More than 20 percent but less than 30 percent	1,464	23.0	23.7	6,680	16.1	16.8
	30 percent or more	1,377	21.6	14.1	3,920	9.4	7.7
	Total	6,373	100.0	100.0	41,612	100.0	100.0

GEOGRAPHIC REGION

FNS has seven regional offices serving States within distinct geographic areas. Each vendor is associated with a particular region, and this information is recorded in the TIP file. As can be seen in Exhibit A5 below, for FY 2005-2009, the majority of investigated vendors were in the Northeast (43.4%-50.7%), although that region accounted for only 16.2 to 17.3 percent of all vendors (see Exhibits A5 & A6). The Southeast was less likely to be investigated relative to its proportion of the vendor population (11.1 to 13.3 % versus 21.1 to 22.2 %). The high number of investigated stores in the Northeast region is due to the fact that New York chooses to investigate a disproportionately higher proportion of vendors than all other States.

Exhibit A5. Investigated Vendors by Fiscal Year (TIP 2005-2009)

Geographic Region	2005		2006		2007		2008		2009	
	#	%	#	%	#	%	#	%	#	%
Mid-Atlantic	347	6.2	310	6.8	351	7.4	361	5.4	457	7.2
Midwestern	713	12.8	484	10.6	686	14.4	850	12.8	924	14.5
Mountain Pacific	171	3.0	159	3.5	201	4.2	237	3.5	261	4.1
Northeast	2,555	46.0	2,260	49.7	2,061	43.4	3,368	50.7	3,129	49.1
Southeast	683	12.3	589	13.0	634	13.3	736	11.1	705	11.1
Southwest	540	9.7	318	7.0	362	7.6	610	9.2	518	8.1
Western	549	9.9	428	9.4	459	9.7	484	7.3	379	5.9
Total	5,558	100.0	4,548	100.0	4,754	100.0	6,646	100.0	6,373	100.0

Exhibit A6. All Vendors by Fiscal Year (TIP 2005-2009)

Geographic Region	2005		2006		2007		2008		2009	
	#	%	#	%	#	%	#	%	#	%
Mid-Atlantic	4,227	9.7	4,588	10.6	4,587	10.5	4,710	10.8	4,750	11.4
Midwestern	7,458	17.0	7,258	16.8	7,831	17.9	7,725	17.8	7,220	17.4
Mountain Pacific	3,436	7.9	3,439	8.0	3,365	7.7	3,330	7.7	3,242	7.8
Northeast	7,581	17.3	7,403	17.1	7,313	16.7	7,240	16.7	6,759	16.2
Southeast	9,726	22.2	9,291	21.5	9,397	21.5	9,292	21.4	8,782	21.1
Southwest	4,829	11.3	4,632	10.7	4,445	10.2	4,323	9.9	4,179	10.0
Western	6,504	14.9	6,597	15.3	6,785	15.5	6,813	15.7	6,680	16.1
Total	43,761	100.0	43,208	100.0	43,723	100.0	43,333	100.0	41,612	100.0

NEW VENDORS

A new vendor is identified in TIP as a vendor who was not authorized at the beginning of the fiscal year but became authorized during the fiscal year. Relative to their representation in the vendor population, new vendors were investigated at a higher rate than existing vendors. About 9.1-12.5 percent of the new vendors were investigated, yet they represented about 6.8 to 8.4 percent of the vendor population (see Exhibit A7 and A8).

Exhibit A7. Investigated Vendors by Tenure (TIP 2005-2009)

New Vendor	2005		2006		2007		2008		2009	
	#	%	#	%	#	%	#	%	#	%
No	4,865	87.5	4,109	90.4	4,322	90.9	6,002	90.3	5,762	90.4
Yes	693	12.5	439	9.7	432	9.1	644	9.7	611	9.6
Total	5,558	100.0	4,548	100.0	4,754	100.0	6,646	100.0	6,373	100.0

Exhibit A8. All Vendors by Tenure (TIP 2005-2009)

New Vendor	2005		2006		2007		2008		2009	
	#	%	#	%	#	%	#	%	#	%
No	40,465	92.5	40,267	93.2	40,446	92.5	40,034	92.2	38,115	91.6
Yes	3,296	7.5	2,941	6.8	3,277	7.5	3,399	7.8	3,497	8.4
Total	43,761	100.0	43,208	100.0	43,723	100.0	43,433	100.0	41,612	100.0

CHILDREN UNDER 5

Using Census data matched to the vendor's ZIP Code, the percentage of children under 5 was calculated. More of the vendors in areas with high densities of children under 5 were investigated than vendors in areas with low densities. For example, vendors in areas with the highest densities of children under 5 accounted for 34.6 to 37 percent of all investigated vendors—about 10 percent greater than their proportion of the vendor population , which ranged from 24.9 to 25.5 (see Exhibit A9). This was also the case when redemption dollars were examined.

Exhibit A9. Investigated Vendors by Percentage of Children Under 5 (TIP 2005-2009)

% of Children Under 5	2005		2006		2007		2008		2009	
	#	%	#	%	#	%	#	%	#	%
Less than or equal to 5.86 %	1,112	20.0	774	17.0	886	18.6	1,164	17.5	1,075	16.9
Greater than 5.86 % but less than or equal to 6.78 %	1,116	20.1	935	20.6	931	19.6	1,340	20.2	1,223	19.2
Greater than 6.78 % but less than or equal to 7.89 %	1,408	25.3	1,158	25.5	1,253	26.4	1,801	27.1	1,766	27.7
Greater than 7.89 %	1,922	34.6	1,681	37.0	1,684	35.4	2,341	35.2	2,309	36.2
Total	5,558	100.0	4,548	100.0	4,754	100.0	6,646	100.0	6,373	100.0

Exhibit A10. All Vendors by Percentage of Children Under 5 (TIP 2005-2009)

% of Children Under 5	2005		2006		2007		2008		2009	
	#	%	#	%	#	%	#	%	#	%
Less than or equal to 5.86 %	11,002	25.1	10,830	25.1	10,930	25.0	10,934	25.2	10,392	25.0
Greater than 5.86 % but less than or equal to 6.78 %	10,723	25.5	10,568	24.5	10,981	24.7	10,844	25.0	10,228	24.6
Greater than 6.78 % but less than or equal to 7.89 %	10,903	24.9	10,812	25.0	10,899	24.9	10,822	24.9	10,374	24.9
Greater than 7.89 %	11,133	25.4	10,998	25.5	11,113	25.4	10,833	24.9	10,618	25.5
Total	43,761	100.0	43,208	100.0	43,723	100.0	43,433	100.0	41,612	100.0

CHILDREN UNDER 1 (INFANTS)

The percentage of infants (children under 1 year of age) was also calculated from Census data matched with the vendor's ZIP Code. Similar to children under 5, investigated vendors in areas with a high density of infants constituted 33.7 to 40 percent of all investigated vendors, while all vendors in areas of high infant density accounted for 24.7 to 25.5 percent of total vendors (see Exhibits A11 & A12).

Exhibit A11. Investigated Vendors by Percentage of Infants Under 1 (TIP 2005-2009)

% of Children Under 5	2005		2006		2007		2008		2009	
	#	%	#	%	#	%	#	%	#	%
Less than or equal to 1.11 %	1,034	18.6	744	16.4	829	17.4	1,189	17.9	999	15.7
Greater than 1.11 % but less than or equal to 1.37 %	1,118	21.4	995	21.9	942	19.8	1,229	18.5	1,330	20.9
Greater than 1.37 % but less than or equal to 1.66 %	1,463	26.3	1,159	25.5	1,209	25.4	1,571	23.6	1,807	28.4
Greater than 1.66 %	1,873	33.7	1,650	36.3	1,774	37.3	2,657	40.0	2,237	35.1
Total	5,558	100.0	4,548	100.0	4,754	100.0	6,646	100.0	6,373	100.0

Exhibit A12. All Vendors by Percentage of Infants Under 1 (TIP 2005-2009)

% of Children Under 5	2005		2006		2007		2008		2009	
	#	%	#	%	#	%	#	%	#	%
Less than or equal to 1.11 %	10.960	25.1	10,811	25.0	11,099	25.4	11,073	25.5	10,404	24.0
Greater than 1.11 % but less than or equal to 1.37 %	11,796	24.7	10,629	24.6	10,749	24.6	10,837	24.9	10,255	24.6
Greater than 1.37 % but less than or equal to 1.66 %	10,926	25.0	10,800	25.0	10,862	24.8	10,814	24.9	10,359	24.9
Greater than 1.66 %	11,079	25.3	10,968	25.4	11,013	25.2	10,709	24.7	10,594	25.5
Total	43,761	100.0	43,208	100.0	43,723	100.0	43,433	100.0	41,612	100.0

APPENDIX B: METHODOLOGY FOR THE ESTIMATION OF OVERCHARGE

APPENDIX B

METHODOLOGY FOR THE ESTIMATION OF OVERCHARGE

DEFINITION AND DISCUSSION OF OVERCHARGE VIOLATIONS

For the purpose of this study, an overcharge occurs when the WIC Program makes a payment to a vendor (for a food item) that is greater than the price that a non-WIC customer would have paid. This definition is consistent with the TIP data system and the 2005 bookend study.

Operationally, however, there are a number of differences between the overcharge definitions used in TIP and the 2005 bookend study. First, the definition used by State investigators and recorded in the TIP file is associated with a sanction, which occurs when a vendor displays a pattern of overcharges. Because one overcharge does not constitute a pattern, a single instance will likely not result in a sanction. The TIP file, therefore, reveals only recurring overcharge behavior. In the 2005 bookend study, however, an overcharge is defined as a single occurrence of an overcharge on a particular buy. By this definition, a single occurrence would not necessarily reflect a pattern of overcharging, which creates a lower threshold for recording overcharges. Thus, if the two studies examined the same population, the proportion of vendors overcharging would be expected to be larger in the 2005 bookend study than in this update based on TIP.

A second difference in the overcharge definitions reflects how overcharging relates to safe buys (the purchase of items specified on the food instrument), partial buys (the purchase of only some of the items specified on the food instrument), and substitutions (the replacement of an item on the food instrument with another item). With regard to safe buys, overcharge has one meaning, which is the amount charged by the retailer over and above the amount that should have been charged for the items on the food instrument. With regard to partial buys and substitutions, overcharges can occur in two ways:

- As in a safe buy, an overcharge can occur with regard to a particular item that is bought (e.g., peanut butter is charged at $2.40 rather than $2.20).

- An overcharge may reflect a charge that occurs with regard to an item that is specified on the food instrument but is not purchased (e.g., the vendor charged for peanut butter at $2.20, which the WIC shopper did not receive).

Partial buys and substitutions were included in the 2005 bookend study. WIC investigations data recorded in TIP do not provide any evidence of the kind of buy that was used, thus resulting in our inability to exactly replicate the 2005 bookend study in this regard. The working assumption is that TIP investigations data represent safe buys. Consistent with this assumption, the 2005 bookend study statistics were used for certain adjustments, as explained below. The use of this information may lead to the underestimation of overcharge rates.

DESCRIPTION OF THE ESTIMATION APPROACH FOR OVERCHARGES

The estimation approach for overcharges involved three steps:

- Estimation of weights that allow sample information to be translated to the population of vendors
- Application of those weights to vendor redemption dollar information
- Application of an adjustment factor for characterizing vendors' improper payment behaviors

These steps are described in the following sections.

Estimation of Weights That Allow Sample Information To Be Translated to the Population of Vendors

The approach used for developing overcharge estimates is a post-stratification adjustment known as raking.

The following illustration provides an explanation of the raking process. Suppose we have a vendor population of 10,000 and a sample of 1,000 investigated vendors. Starting with a two-dimensional matrix, with three categories within each dimension, suppose the population of 10,000 vendors is scattered across the cells as shown in Exhibit B1. Suppose the sample of investigated vendors (1,000 retailers) is also scattered across the same nine cells as shown on Exhibit B2. In comparing Exhibits B1 and B2, it can be seen that the sample is not consistent with the population in terms of proportionality—with representation overstated in certain categories and understated in others. The object of raking is to determine weights that would allow translation of the sample to the population so that the sample is truly representative of the population.

Exhibit B1. Vendor Population Distributed Across Two Dimensions

Dimension 1 (e.g., urbanization)	**Dimension 2 (e.g., poverty)**			
	Low	Medium	High	Total
Low	300	400	300	1,000
Medium	1,500	1,500	1,000	4,000
High	700	600	3,700	5,000
Total	2,500	2,500	5,000	10,000

Source: WIC Erroneous Payments to Vendors: Methodology for Developing Annual Estimates for 2005.

Exhibit B2. Vendor Sample Distributed Across Two Dimensions

Dimension 1 (e.g., urbanization)	Dimension 2 (e.g., poverty)			
	Low	Medium	High	Total
Low	40	60	100	200
Medium	100	200	200	500
High	60	40	200	300
Total	200	300	500	1,000

Source: WIC Erroneous Payments to Vendors: Methodology for Developing Annual Estimates for 2005.

Exhibit B3 shows the example of the initial raking matrix. The cell entries represent sample values, and the marginal totals represent population values. As discussed above, the idea of raking is to identify values for the cells that will add up to the marginal population values. Each value would be assigned a weight that allows this transformation to occur. Multiple iterations are needed to accomplish this when the transformation involves two or more dimensions.

Exhibit B3. Initial Raking Matrix

Dimension 1 (e.g., urbanization)	Dimension 2 (e.g., poverty)			
	Low	Medium	High	Population Values
Low	40	60	100	1,000
Medium	100	200	200	4,000
High	60	40	200	5,000
Population Values	2,500	2,500	5,000	10,000

Source: WIC Erroneous Payments to Vendors: Methodology for Developing Annual Estimates for 2005.

On the first iteration, the weight is calculated by dividing the population total by the sum of the cell sample values (see Exhibit B4). Thus 1,000 is divided by 200 for a weight of five, and so on.

Exhibit B4. Marginal Frequencies and Percentages for the Population and Sample

Dimension		Population (Marginals)		Sample (Marginals)		Weight
		No.	%	No.	Pct.	
Dimension 1	Low	1,000	10%	200	20%	5
	Medium	4,000	40%	500	50%	8
	High	5,000	50%	300	30%	16.7
	Total	10,000	100%	1,000	100%	
Dimension 2	Level 1	2,500	25%	200	20%	*
	Level 2	2,500	25%	300	30%	*
	Level 3	5,000	50%	500	50%	*
	Total	10,000	100%	1,000	100%	

Source: WIC Erroneous Payments to Vendors: Methodology for Developing Annual Estimates for 2005.

Next, new sample cell frequencies are calculated by applying the weights to the original sample cell frequency (see Exhibit B5). These new cell frequencies will add to the dimension 1 marginals, but not to the dimension 2 marginals. Therefore, we have to adjust the cell values to the dimension 2 marginals.

Exhibit B5. Weights Resulting From Initial Rake

Dimension 1	Dimension 2	Original Sample Cell Frequency	Weights From Initial Rake (Exhibit 4)	New Cell Frequency
Low	Low	40	5	200
	Medium	60	5	300
	High	100	5	500
Medium	Low	100	8	800
	Medium	200	8	1,600
	High	200	8	1,600
High	Low	60	16.7	1,000
	Medium	40	16.7	760
	High	200	16.7	3340

Source: WIC Erroneous Payments to Vendors: Methodology for Developing Annual Estimates for 2005.

The second step is to divide the population marginals for dimension 2 by the new cell frequencies summed over dimension 2. This gives a whole new set of weights (see Exhibit B6). Note that dimension 1 is ignored in this iteration.

Exhibit B6. Marginal Frequencies and Percentages for the Population and Sample

		Population (Marginals)		New Cell Frequencies (Marginals)		Weight
		No.	%	No.	Pct.	
Dimension 1	Low	1,000	10%	1,000	20%	*
	Medium	4,000	40%	4,000	50%	*
	High	5,000	50%	5,000	30%	*
	Total	10,000	100%	10,000	100%	
Dimension 2	Level 1	2,500	25%	2,000	20%	1.25
	Level 2	2,500	25%	2,660	27%	.94
	Level 3	5,000	50%	5,340	53%	.94
	Total	10,000	100%	10,000	100%	

Source: WIC Erroneous Payments to Vendors: Methodology for Developing Annual Estimates for 2005.

When the dimension 2 weights are applied to the cell frequencies, we get the results displayed in Exhibit B7. The cell values when added sum to the dimension 2 marginals; however, they lose their coherence with dimension 1 marginal values. To ensure that the cell values maintain coherence to both the first and second dimensions, we repeat the rakings, first across dimension 1, then over dimension 2. Each repetition will result in values that are closer to the population values. Raking will be completed when the marginals calculated from the cell values equal, or are close to, the population marginals for all dimensions. The ultimate weight after these iterations will represent the number of vendors represented by each sample point. For the purposes of generating weights, routine monitoring visits were not considered an investigation. In any case, monitoring was excluded from the numbers in the report itself. It should be noted that in identifying overcharge violations, the focus is only on those violations in which the State indicated that the reason for sanction was an overcharge. Other violations, such as substitutions or trafficking, were not counted as violations for this study.

Exhibit B7. Weights Resulting From Initial Rake

Dimension 1	Dimension 2	New Cell Frequency	Weights From Initial Rake	New Cell Frequency After Dimension 2 Rake
Low	Low	200	1.25	250
	Medium	300	.94	282
	High	500	.94	470
Medium	Low	800	1.25	1,000
	Medium	1,600	.94	1,504
	High	1,600	.94	1,504

High	Low	1,000	1.25	1,250
	Medium	760	.94	714
	High	3,340	.94	3,140

Source: WIC Erroneous Payments to Vendors: Methodology for Developing Annual Estimates for 2005.

The raking procedure attempts to translate sample results to the population through a set of characteristics. The five characteristics over which the data were raked were vendor type, ownership, urbanization, poverty level, and redemption dollar quartile. These characteristics were chosen on the basis of previous research on the Supplemental Nutrition Assistance Program (SNAP) (formerly the Food Stamp Program) showing the relationships among food stamp trafficking, vendor characteristics, and neighborhood characteristics.[6] That research, although focused on SNAP, was thought to substantiate a basic set of indicators that would be useful for characterizing WIC transactions as well. The variables were examined and modified to be more appropriate to examining WIC over- and undercharges.

Application of Weights to Vendor Redemption Dollar Information

Raking weights were used to provide initial estimates. The population estimate of the number of stores that overcharge was the sum of the weighted number of stores found to be overcharging within the sample. The vendor-based overcharge rate was the weighted number of overcharging vendors divided by the total number of vendors in the population. The unadjusted value of overcharges was the sum of the weighted redemption dollars represented by the stores that were found to be overcharging within the sample. The unadjusted redemption-based overcharge rate was the amount of overcharge found in the population of overcharging vendors divided by the total amount of redemption dollars reported in the population. An error was deemed to have occurred if TIP data indicate that a vendor was sanctioned for overcharging. The definition of the error indicator was expanded to include sanctions in SNAP.

To estimate the variance associated with the raking estimates, a bootstrap approach in which estimates were made for random samples selected from investigated cases was used.[7] This allows for the identification of a standard deviation and a minimum and maximum associated with the estimation procedure.

[6] See U.S. Department of Agriculture, Food and Nutrition Service, Office of Analysis, Nutrition and Evaluation (2003). *The Extent of Trafficking in the Food Stamp Program: 1999–2002*, FSP-03-TRAF, by Theodore F. Macaluso, Ph.D., Alexandria, VA, and U.S. Department of Agriculture, Food and Nutrition Service, Office of Analysis, Nutrition and Evaluation (2000). *The Extent of Trafficking in the Food Stamp Program: An Update*, by Theodore F. Macaluso, Ph.D., Alexandria, VA.

[7] Samples were drawn from the investigative files and subjected to the raking algorithm. Each sample provided a mean. A grand mean and a standard deviation were estimated across all these samples.

Application of an Adjustment Factor for Characterizing Vendors' Improper Payment Behaviors

The overcharge estimate in Exhibit B8 represents all redemption dollars in stores that overcharge. Because we would expect that not all of these redemption dollars are overcharges, the figures need to be adjusted. This section describes the adjustment approach.

The 2005 Bookend study provides data that are useful in computing this adjustment factor. It examined three buys (safe, partial, and substitution) in which purchases were made from particular sampled vendors using food instruments. The study provides information on the actual amount the vendor charged for each type of buy and the amount that was supposed to be charged. Thus, overcharges can be identified as a percentage of the total value of the food instruments that were redeemed. For the purposes of this study, we will focus on safe buys.

Exhibit B8 shows that the average overcharge is $1.82 for safe buys in the 2005 Bookend Study. It should be noted that this amount reflects the activities of only those vendors that overcharged, which are very few. The data also show that the amount of overcharge was very small in many cases. For example, for safe buys the minimum overcharge was $0.02, with 25 percent of all safe buy overcharges valued at less than $0.20.

Exhibit B8. Weighted Distribution of Overcharges in the 2005 Bookend Study by Buy Type

Buy Type	N	Average	Minimum	25th Percentile	Median	75th Percentile	Maximum
Safe	46	$1.82	$0.02	$0.20	$0.64	$2.01	$10.00
Partial	65	$7.86	$0.02	$0.44	$2.39	$7.87	$65.54
Minor substitution	39	$4.38	$0.01	$0.30	$0.71	$2.40	$67.00
Major substitution	24	$1.57	$0.02	$0.20	$0.60	$2.16	$9.30

Source: WIC Erroneous Payments to Vendors: Methodology for Developing Annual Estimates for 2005.

Exhibit B9 presents the distributional characteristics of this adjustment factor of 10.7 percent.

Exhibit B9. Mean 2005 Bookend Study Overcharge as a Percentage of the Food Instrument for Safe Buys Only

Number of Safe Buy Overcharges	Mean Overcharge Percent	Standard Deviation	Minimum	Maximum
46	10.74	77.87	0.07	73.64

Source: WIC Erroneous Payments to Vendors: Methodology for Developing Annual Estimates for 2005.

APPENDIX C: METHODOLOGY FOR THE ESTIMATION OF UNDERCHARGE

APPENDIX C

METHODOLOGY FOR THE ESTIMATION OF UNDERCHARGE

DEFINITION AND DISCUSSION OF UNDERCHARGES

A formal definition of an undercharge in the WIC Program does not exist in the Code of Federal Regulations or the 10 State vendor agreements and handbooks reviewed as part of this research. However, the 2005 Bookend study defined an undercharge as a negative difference between the redeemed value of a food instrument and the best retail price for the food bundle as recorded by field data collectors. This study also used this definition.

Unlike overcharges, undercharges are not recorded in the TIP data system and have not been used to issue sanctions. Therefore, both the probability of a vendor transacting an undercharge and the dollar amount of an undercharge were estimated using the 2005 Bookend study applied to the TIP data. This means that when applied to TIP data in subsequent years, the total expected value of undercharges will change strictly as a function of changes in redemption amounts and the characteristics of the population of WIC vendors.

The 2005 Bookend study allowed retailers to undercharge on any of three types of buys. As shown in Exhibit C1, the number of vendors undercharging in any one of the three buys is approximately 10 percent, which is equivalent to the result for overcharging when all three buy types are taken into consideration.

Exhibit C1. Weighted Frequency of Vendors with Undercharges (2005 Bookend Study)

Number of Undercharges	Weighted Frequency	Percent	Cumulative Frequency	Cumulative Percent
No undercharges	33,318	89.71	33,318	89.71
One undercharge	3,384	9.11	36,702	98.83
Two undercharges	346	0.93	37,047	99.76
Three undercharges	90	0.24	37,138	100

Source: WIC Erroneous Payments to Vendors: Methodology for Developing Annual Estimates for 2005.

The proportion of vendors undercharging by type of buy is presented in Exhibit C2. The results show that the percentage of vendors undercharging on partial buys was lower than for other buys. Vendors were more likely to undercharge for major substitutions than for partial, safe, or minor substitution buys.

Exhibit C2. Weighted Frequency of Undercharges in the 2005 Bookend Study by Buy Type*

Buy Type	Undercharge		No Undercharge		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Safe	1,554	4.6	32,289	95.4	33,843	100.0
Partial	971	2.9	32,681	97.1	33,651	100.0
Minor substitution	1,131	5.1	20,995	94.9	22,127	100.0
Major substitution	656	6.0	10,308	94.0	10,963	100.0
Total	4,312	4.3	96,273	95.7	100,585	100.0

* Numbers represent the number of buys, not vendors.

Source: WIC Erroneous Payments to Vendors: Methodology for Developing Annual Estimates for 2005.

With regard to the dollar amount, the average undercharges were $0.94 for safe buys, $1.43 for partial buys, $2.41 for minor substitutions, and $0.96 for major substitutions (see Exhibit C3).

Exhibit C3. Weighted Distribution of Undercharges in the 2005 Bookend Study by Buy Type

Buy Type	N	Average	Minimum	25th Percentile	Median	75th Percentile	Maximum
Safe	74	-$0.94	-$5.43	-$1.16	-$0.49	-$0.18	-$0.01
Partial	40	-$1.43	-$9.00	-$2.09	-$0.60	-$0.20	-$0.01
Minor substitution	51	-$2.41	-$14.67	-$3.00	-$1.20	-$0.40	-$0.01
Major substitution	23	-$0.96	-$3.00	-$1.42	-$0.50	-$0.23	-$0.02

Source: WIC Erroneous Payments to Vendors: Methodology for Developing Annual Estimates for 2005.

As shown in Exhibit C4, undercharges ranged from 7 percent (safe buys) to almost 12 percent (partial and minor substitution buys) of the total value of the food instrument, which supports the claim that undercharges vary with the kind of interactions that WIC participants have with WIC vendors. However, because the relative frequency of the natural occurrence of buy types cannot be determined and because these estimates are meant to build on the 2005 Bookend study results, only safe buys were used to generate estimates of undercharges.

Exhibit C4. Weighted Distribution of Undercharges as a Percentage of Food Instrument Value in the 2005 Bookend Study by Buy Type

Buy Type	N	Mean Percent	Minimum Percent	25th Percentile	Median	75th Percentile	Maximum
Safe	74	7.211	0.098	1.147	3.511	7.567	46.530
Partial	40	11.786	0.072	1.715	6.834	13.599	91.667
Minor substitution	51	11.759	0.031	1.105	6.651	16.534	71.030
Major substitution	23	5.483	0.314	1.401	3.840	8.186	25.063

Source: WIC Erroneous Payments to Vendors: Methodology for Developing Annual Estimates for 2005.

STRATEGY FOR ESTIMATING UNDERCHARGES

Because the TIP files do not contain any information about undercharges, any estimate must be based solely on the undercharge behavior of vendors sampled for the 2005 bookend study. Our approach involved developing predictive equations based on behaviors revealed in safe buys only. In developing a predictive equation, logistic regression was used to model the probability of a vendor undercharge, and ordinary least squares regression techniques were used to model the amount of an undercharge.

The first step was to predict the probability of an undercharge. A predictive equation using a logit model was generated from the weighted 2005 bookend study sample. Because it is the probability of undercharging that is modeled at this stage, logistic regression is appropriate because it is nonlinear, allowing the modeler to take into account the fact that probabilities are bound at 0 and 1. The vendor characteristics used as predictors were:

- Store type, expressed as a series of nominal variables, one each for large retailers, small retailers, WIC-only vendors, and an indicator for all other types of vendors. It should be noted that the 2005 bookend study did not include pharmacies that provided only

special infant formula,[8] commissaries, direct vendors, or home delivery vendors in its sample. As a result, the indicator for "all other types of vendors" was necessarily estimated based on WIC above-50-percent vendors only.

- Ownership type, either public or private
- Percentage of families within the vendor's ZIP Code living in a Census Bureau-designated urban setting
- Percentage of households within the vendor's ZIP Code living at or below the poverty level
- Vendor's total annual WIC redemption dollars in 2005

Next the logistic regressions, as estimated, were applied to all vendors in the TIP file, and the resulting log odds ratios were converted to probabilities. The equation that was applied is specified as follows:

$$P_v = 1/(1 + \exp(-(-1.8174 + 0.0598*U_v + 1.5633*PO_v - 3.54*(1/10^7)*R_v - 1.6523*LR_v - 1.2922*SR_v - 0.4434*WO_v - 0.0475*PU_v + 0.0835*PR_v)))$$

Where P_v is the probability that the vendor undercharged

U_v is the percentage of the population living in urban areas within the vendor's ZIP Code

PO_v is the percentage of households living in poverty within the vendor's ZIP Code

R_v is the annual amount of redemptions for that vendor

LR_v is whether the vendor is a large retailer

SR_v is whether the vendor is a small retailer

WO_v is whether the vendor is a WIC-only store

PU_v is whether the vendor is publicly owned

PR_v is whether the vendor is privately owned

The second step was to predict the expected dollar value of an undercharge. Linear regression was appropriate because the predicted (dependent) variable is continuous, and unlike probabilities, there was no reason to expect a nonlinear relationship. The regression only used those cases of undercharging in the estimation procedure. Thus it provided the amount of the average undercharge, given certain vendor characteristics, if the vendor undercharged.

These predictive equations were applied to all vendors in the TIP file. Again, all values were predicted for each vendor using the parameters estimated based on safe buys. When predicting from the TIP file, total redemption dollars were substituted for the value of the food instrument

[8] Because the focus was on food outlays, it was difficult on a store-to-store basis to isolate formula sales from food outlay sales. We made a decision to exclude pharmacies because most would sell formula and although some would sell food, they would probably account for a small portion of overall food sales.

that was used when generating the equation from the 2005 bookend study data. The prediction equation is specified as follows:

$$EU_v = \mathbf{0.07302} - \mathbf{0.01322}*U_v - \mathbf{0.20337}*PO_v + \mathbf{2.496827}*(\mathbf{1/10^8})*R_v + \mathbf{0.04108}*LR_v + \mathbf{0.06282}*SR_v + \mathbf{0.03089}*WO_v - \mathbf{0.00542}*PU_v$$

Where EU_v is the expected underpayment to the vendor given that they undercharged

U_v is the percentage of the population living in urban areas within the vendor's ZIP Code

PO_v is the percentage of households living in poverty within the vendor's ZIP Code

R_v is the annual amount of redemptions for that vendor

LR_v is whether the vendor is a large retailer

SR_v is whether the vendor is a small retailer

WO_v is whether the vendor is a WIC-only store

PU_v is whether the vendor is publicly owned

The third step was to obtain the expected amount of an undercharge for each vendor in the TIP file. Multiplying the probability of undercharging (step 1) by the average amount undercharged (step 2) produced an expected value for undercharges for each vendor. This value represents the total dollar amount undercharged. This is represented as follows:

$$AU_v = R_v*P_v*EU_v$$

Where AU_v is the final adjusted undercharge for vendor v; the other factors are defined above.

The vendor undercharge rate was calculated by summing the probabilities of undercharging across all vendors in the TIP file, and the redemption undercharge rate was calculated by determining the total amount of undercharges as a percentage of all redemption dollars.