Introduction to the SIMPLE macro,
a tool to increase the accessibility of 24-h dietary analysis and modelling
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Online Supplementary Material

Online Supplemental User Manual 1

SIMPLE Macro User Manual

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SIMPLE-Iron Macro version: 2.18
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Acronyms and Abbreviations

24HRs	24-hour dietary recalls
BM	Breast milk
BRR	Balanced Repeated Replication
CNMS	Cameroon National Micronutrient Survey
DS	Dietary Supplements
EAR	Estimated Average Requirement
IOM	Institute of Medicine
IQR	interquartile range
NHANES	National Health and Nutrition Examination Survey
OC	Oral Contraceptive
SEs	Standard errors
SIMPLE	Simulating Intake of Micronutrients for Policy Learning and Engagement
UL	Tolerable Upper Intake Level

1. Introduction

The Simulating Intake of Micronutrients for Policy Learning and Engagement (SIMPLE) macro is a 'wrapper' for the National Cancer Institute MIXTRAN, DISTRIB, and BOXCOX_SURVEY macros to facilitate estimation of usual intake distributions for food and nutrients consumed 'nearly-daily'. The SIMPLE macro supports a variety of analyses, including estimating usual nutrient intake and modelling nutrition-related interventions that may be of interest to policy advocates and researchers. The SIMPLE macro can be used to analyze data from 24-hour dietary recalls (24HRs), 24-hour food records, and 24-hour food intake observations.

The SIMPLE macro first checks the inputted datasets and macro parameters for formatting and model specification errors before starting analysis; if any detectable errors are found, the macro provides guidance for correcting them. Output from a successful run includes a formatted spreadsheet (suitable for use in reports or manuscripts) containing estimates and associated standard errors (SEs) for characteristics of the usual intake distribution, such as the mean, median, interquartile range (IQR), and proportions of the population with inadequate or excessive nutrient intake. The core SIMPLE macro estimates inadequate or excessive nutrient intake using the IOM Estimated Average Requirement (EAR) cutoff method, defining inadequate intake as intake below the user-specified age- and sex-specific EAR for a given nutrient, and excessive intake as intake above the corresponding Tolerable Upper Intake Level (UL) (1). The SIMPLE macro also outputs model parameters such as within- and between-person variance components and coefficients for included covariates that influence the distribution of usual intake.

In addition, there are two variations to the SIMPLE macro. The SIMPLE-1D macro can be applied for descriptive or modeling analyses when only a single 24HR per person has been collected and the SIMPLE-Iron macro allows estimation of inadequate nutrient intake using the full probability approach.

In what follows, we describe the general requirements for running the SIMPLE macro and then present four example analyses for the purpose of illustrating the potential applications of the SIMPLE macro. The code, sample data, and this user guide are available as supplemental material (Open Science Framework: https://osf.io/ytd34/).

- **Example 1** uses data from adult women in the National Health and Nutrition Examination Survey (NHANES) 2011–2014 survey (2) to perform a descriptive analysis of usual calcium intake from food sources alone and from the combination of food sources and dietary supplements (DS).
- **Example 2** uses the same data from NHANES to estimate inadequate iron intake using the full probability method among children and teenagers 9 – 18 years old with the SIMPLE-Iron macro.
- **Example 3** uses data from the Cameroon National Micronutrient Survey (CNMS) (3) to model the effects of hypothetical vitamin A fortification and supplementation programs among preschool children, accounting for the contribution of breast milk (BM) intake to vitamin A intake.
- **Example 4** uses only the first 24HR per person from the CNMS and implements the same analyses as the third example, to illustrate use of the SIMPLE-1D macro.

We strongly recommend that users thoroughly review the NCI measurement error webinar series (4) and the measurement error webpage (5) that explains the theory underpinning the

SIMPLE macro. We also recommend that users personally work through the provided examples to gain practical experience before applying the SIMPLE macro to their own studies.

2. General requirements and tips for successfully using the SIMPLE macro

2.1. General requirements of the SIMPLE macro

The SIMPLE macro and its extensions are built using the public available NCI macros and thus requires all the same general requirements as the NCI macros.

Minimum system requirements:

- SAS® 9.4 software (available from: https://www.sas.com/en_us/software/sas9.html);
- Microsoft excel (available from: https://office.microsoft.com/excel)

Minimum knowledge requirements:

- Understanding the theoretical basis for analysis of 24HR data. We recommend that users thoroughly review the NCI measurement error webinar series (available from: https://epi.grants.cancer.gov/events/measurement-error/).
- Understanding basic SAS Software programming. Users can find free SAS courses on the internet. We recommend an introductory SAS courses from Cousera (available from: https://www.coursera.org/learn/sas-programming-basics).

2.2. Tips for successfully using the SIMPLE macro

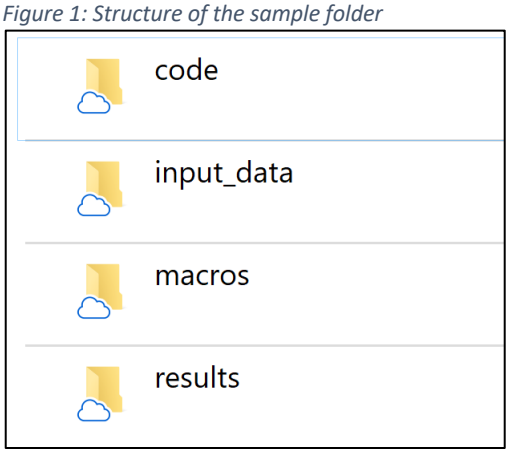
- Depending on the sample size and study design, it may take a long time to complete a successful SIMPLE macro run. Terminating the macro run early is a common cause of errors.
- The log will indicate if the process has been stopped due to errors. Users can save their log file to a text file so they can reference it in the future. Currently, this piece of example code is disabled and provided as notation. Users can enable the code to save their log file into a text file. However, in this case, their log file will not present in the log window because the log is directly saved to the text file.
- To estimate SEs, the user needs to set up the Balanced Repeated Replication (BRR) or Bootstrap replications before running the SIMPLE macro. Please refer to the NHANES Dietary Web Tutorial by the CDC (link: https://www.cdc.gov/nchs/tutorials/Dietary/Advanced/ModelUsualIntake/index.htm) for more information on BRR and its application in the NCI approach for handling measurement error in dietary data. Because running many BRR or bootstrap replications may take a long time, we recommend that the users first change the "endWeight = 3" to test the code. After the code is free of errors, users should change the endWeight to generate the correct SEs.
- The 24HR dataset must be organized in the "long" format, in which each row is a record of a 24HR and there are multiple rows per participant. There will be two rows in the dataset for each participant who completed both the 1st and 2nd 24HRs and one row for each participant who completed only the 1st 24HRs. Users can see an example of the long format data in section 4. 1.

- The covariates can be in the format of either continuous or binary. Categorical variables need to be expressed into multiple binary variable (often-called dummy variables, see instructions here). In example 1 (section 4.1), the variable race has six levels: 1 = Mexican/American; 2 = Other Hispanic; 3 = Non-Hispanic White; 4 = Non-Hispanic Black; 6 = Non-Hispanic Asian; 7 = Other Race - Including Multi-Racial. To use race as a covariate, we need to express categorical variable race in five binary variables, named race1, race2, race4, race6, and race7 and put these five binary variables into the list of covariates. In this case race = 3 is the reference group.
- If users carry out any subgroup analysis, which means that that they estimate usual nutrient intake among different groups, users need to put the subgroup of interest as covariates. For example, in example 1, we are interested in estimating usual intake for difference races, so we need to put the five binary race variables as covariates.
- For dietary analysis and modelling from different data sources (24HRs, DS recalls, BM dataset), the SIMPLE macro allows users to either have all the information in one dataset or keep them separate. Users do not need to merge all the information from different sources into one big dataset.

3. Structure of the example project folder

We provide four example analyses in the following sections. For each example, we prepare one example project folder. Each example project folder follows the same structure containing four subfolders, namely "code", "input_data", "macros", and "results" (**Fig. 1**). Because the sample code was written based on the existing structure of the project folder, to run the SIMPLE macro successfully, *users should download the whole example project folder to their computer and retain the naming and organization of sub-folders and files while running the example analyses*. The content of each folder is described below.

Figure 1: Structure of the sample folder



3.1. Contents of the "code" folder

- **SAS code file ending with .sas:** SAS code to run example analyses using the SIMPLE macro. Users should open this code file to follow along with the user guide.

3.2. Contents of the "input_data" folder

This folder contains sample data used to illustrate the different analysis examples.

3.3. Contents of the "macros" folder

Examples 1 and 3 use the SIMPLE macro, example 2 uses SIMPLE-Iron, and example 4 uses SIMPLE-1D.

- **simple_macro_v2.18**: This is the SIMPLE macro to analyze usual nutrient intake and carry out advanced simulations to estimate the effect of nutrition interventions. This macro will be used in examples 1 and 3 and is available under the corresponding folders.
- **simpleIron_macro_v2.18**: This is the SIMPLE-IRON macro to analyze inadequate *iron* intake and carry out advanced simulations to estimate the effect of iron-related nutrition interventions. This macro will be used in example 2 and is available under the corresponding folder.
- **simple1D_macro_v1.4**: This is the SIMPLE-1D macro, which is used to analyze usual nutrient intake and carry out advanced simulations to estimate the effect of nutrition interventions using one single-day 24HR. This macro will be used in example 4 and is available under corresponding folder.

The SIMPLE macro and its extensions (SIMPLE-iron and SIMPLE-1D) are built using the publicly available NCI MIXTRAN and DISTRIB macros. Therefore, users should always have MIXTRAN and DISTRIB macros under the "macros" folder. The MIXTRAN and DISTRIB macros are provided here as a courtesy. For the latest version, users should download the macros directly from the NCI website at https://prevention.cancer.gov/research-groups/biometry/measurement-error-impact/software-measurement-error/single-regularly-consumed-or-0

- **mixtran_macro_v2.21.sas**: This is the NCI MIXTRAN macro.
- **distrib_macro_v2.2.sas**: This is the NCI DISTRIB macro.

3.4. Contents of the "results" folder

The "results" folder contains the output datasets from the SIMPLE macro for estimating the usual nutrient intake distribution under different scenarios. Output datasets are described briefly below. The contents and use of these files are described in detail in **Section 4.3.**

- Excel (.xlsx) and SAS files (.sas7bdat) starting with "**_final**" contain final analysis results based on outputs from the SIMPLE macro.
- SAS files (.sas7bdat) starting with "**_int**" contain intermediate analysis results based on outputs from the SIMPLE macro.
- SAS files (.sas7bdat) starting with "**_parameter**" contain estimated coefficients of covariates, transformation lambda, and values for the ratio of within- and between-variance.
- Zipped files starting with "**_mcsimData**" contain the Monte Carlo simulation dataset.

4. Example 1: Descriptive analysis using the EAR cutoff point method using NHANES 2011-2014

This example uses data on women 18 years of age and older from NHANES 2011-2014. In this population, individual women have different EAR and UL cutoff values based on their age at the time of survey. The associated sample code demonstrates:

- **Example 1.1**: how to estimate the distribution of usual calcium intake from food sources and the proportion of the population with usual intake using a single cutoff for all individuals; and
- **Example 1.2**: how to estimate the prevalence of inadequate and excessive intake from food sources using the individual-specific EAR and UL cutoffs (i.e., applying appropriate cutoffs to account for an individual's age); and
- **Example 1.3**: how to estimate the prevalence of inadequate and excessive intake accounting for both food sources and DS using appropriate EAR and UL cutoffs for each individual. The BRR method is used to estimate SEs for these results.

In the following sections, we walk through each step of the analysis for **example 1.3**. Example 1.3 is chosen because it is more complicated than the analysis of **examples 1.1 and 1.2**, we hope that users can analyze **examples 1.1 and 1.2** after reading this manual.

4.1. Input datasets

4.1.1. 24-hr dietary recall dataset from NHANES

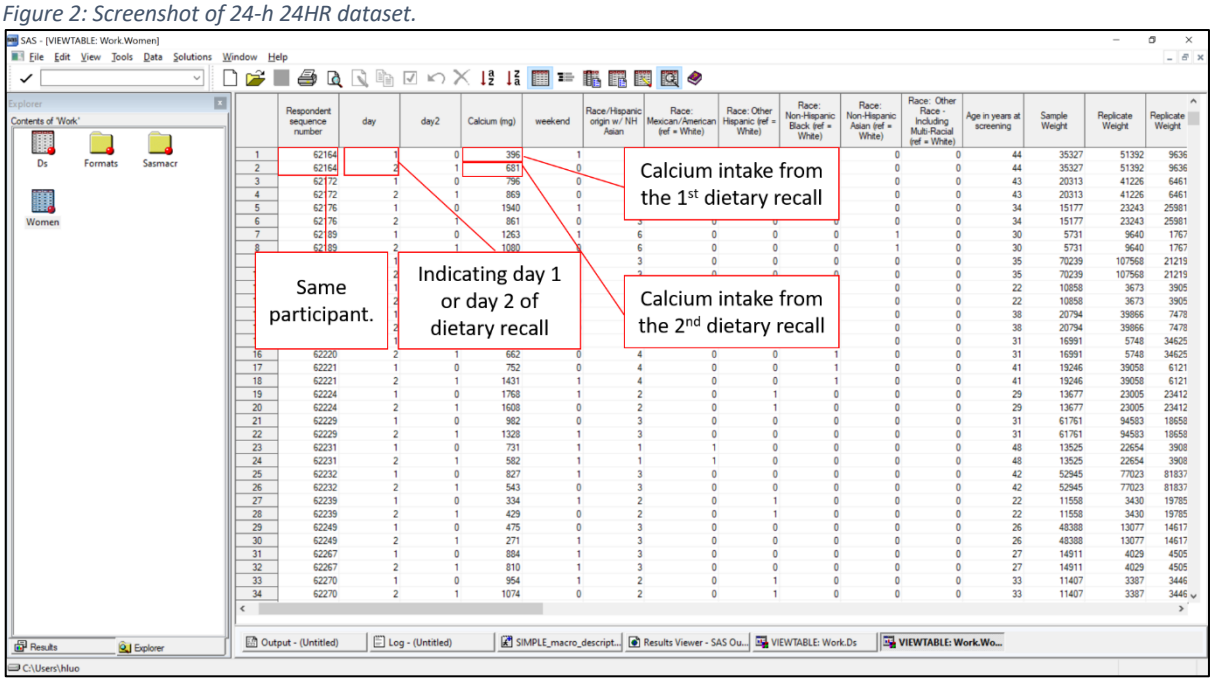
A 24HR dataset with repeat observations in a subsample is required to run the SIMPLE macro. **women.sas7bdat** is a sample SAS data file containing demographic information and 24HRs of women ≥ 50 years old from the NHANES 2011-2014. The sample size is 4110 women, and 3757 of these women have a 2nd 24HR. The 24HR dataset must be organized in the "long" format, in which each row is a record of a 24HR. There will be two rows in the dataset for each woman who completed both the 1st and 2nd 24HRs and one row for each woman who completed only the 1st 24HRs. In the dataset, there are 33 survey weight variables for use in the BRR method for obtaining standard errors. RepWt_0 is the original sample weight, and RepWt_1 to RepWt_32 are 32 hypothetical repeated weights generated from the BRR method.[1] Please refer to the NHANES Dietary Web Tutorial by the CDC at https://www.cdc.gov/nchs/tutorials/Dietary/Advanced/ModelUsualIntake/index.htm for more information on BRR and its application in the NCI approach for handling measurement error in dietary data. The codebook of the 24HR dataset is in **Table 1,** and its screenshot is in **Fig. 2.**

Table 1: Codebook for NHANES 2011-2014 sample dataset for women ≥ 19 years old and children 9 – 18 years old.

variable name	Description	Type
seqn	Unique identifier of each participant	Integer
day	Specifies the number of the day of dietary calls. Variable day is a categorical variable.	1= day 1 of 24HR 2 = day 2 of 24HR
day2	Specifies one or more sequence indicator variables to account for effects due to	Binary variable 1 = the 2nd 24HR 0 = the 1st 24HR.

	the sequence number of a subject's records. Day2 is a binary variable.	
weekend	Specifies a 24HR was collected either on a weekend or weekday.	Binary variable 1 = weekend 0 = weekday
calc	Calcium intake from food (mg/d)	Numeric
race	Specifies race and ethnicity	Categorical variable 1 = Mexican/American; 2 = Other Hispanic; 3 = Non-Hispanic White; 4 = Non-Hispanic Black; 6 = Non-Hispanic Asian 7 = Other Race - Including Multi-Racial
race1	Recode categorical variable "race" into 5 binary variables	Binary variable 1 = Mexican/American 0 = Not Mexican/American
race2	Recode categorical variable "race" into 5 binary variables	Binary variable 1 = Other Hispanic 0 = Not other Hispanic
race4	Recode categorical variable "race" into 5 binary variable	Binary variable 1 = Non-Hispanic Black 0 = Not non-Hispanic Black
race6	Recode categorical variable "race" into 5 binary variable	Binary variable 1 = Non-Hispanic Asian 0 = Not non-Hispanic Asian
race7	Recode categorical variable "race" into 5 binary variable	Binary variable 1 = Other race – including multi-racial 0 = Not other race
gender	Gender of the respondents	1 = male 2 = female
male	Recode gender variable	1 = male 0 = female
ageyr	Age of the participants (unit: years)	Integer
repwt_0	Survey weight	Integer
repwt_1 – repwt_32	Balanced repeated weight 1-32. The 32 balanced repeated weights were generated based on the NHANES guideline.[1]	Integer

Figure 2: Screenshot of 24-h 24HR dataset.



4.1.2. Dietary supplement dataset

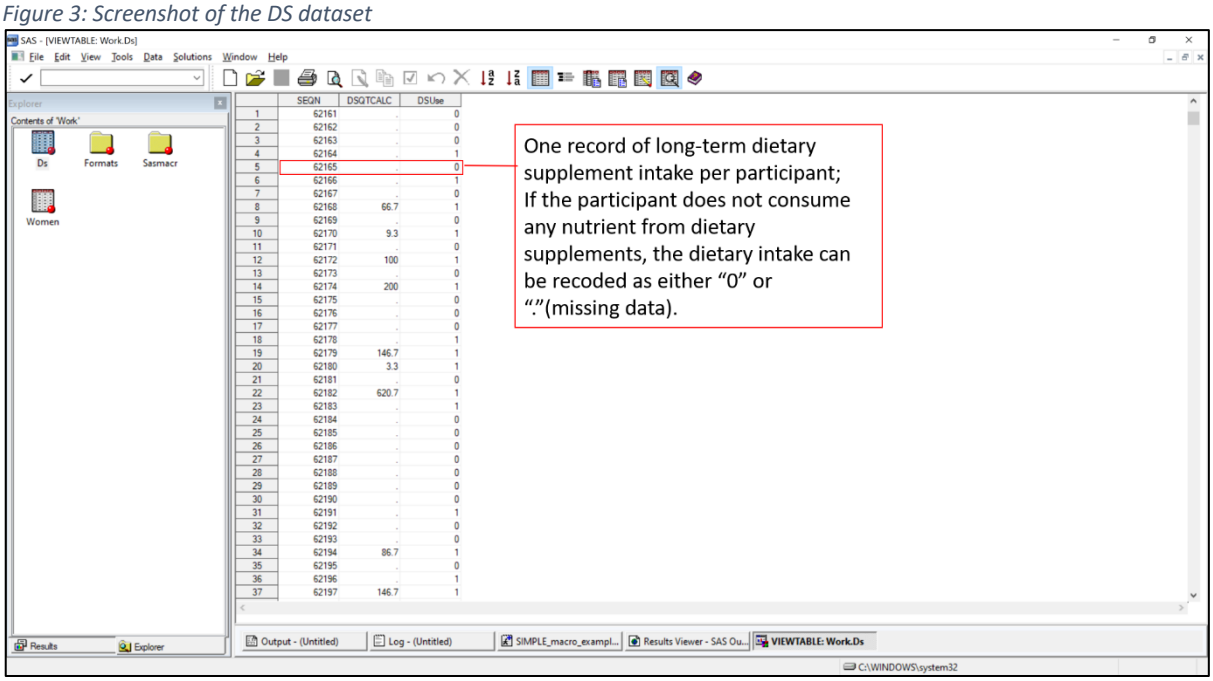
The DS dataset is optional to run the SIMPLE macro. It is only required when users want to estimate the combined intake from food and DS. The SIMPLE macro allows users to either have all the information (24HRs and DS) in one dataset or keep them separate. In this example, **ds.sas7bdat** is a SAS sample data file including the information on DS use and calcium intake from supplements. In the SIMPLE macro, there is one observation of nutrient intake from DS per participant, which is intended to represent usual nutrient intake from supplements for that individual. Nutrient intake from DS is typically measured over a longer period than 24-h (for example, a 30-day supplement questionnaire) and thus reflects long-term average intake. Users could measure long-term supplement intake in many ways. If users just recorded supplements in the past 24h as part of the 24h recall, those data would not really be appropriate here. These calculations should be conducted separately by the user prior to formatting supplement intake estimates for use in the SIMPLE macro.

In this example, the sample size of the supplement dataset is 19931, which includes ALL participants from NHANES 2011-2014. The SIMPLE macro allows the supplement dataset to be larger than the 24HR dataset. It's important to ensure that the participant identifiers correctly identify individual participants in the two datasets (i.e., that supplements can be matched to the appropriate participants). The codebook of the DS dataset is in **table 2**, and the screenshot of this dataset is illustrated in **Fig 3.**

Table 2: Codebook of the DS dataset for NHANES 2011-2014 sample dataset for both women ≥ 19 years old and teenagers 9 -13 years old.

Variable name	Description	Type
seqn	Unique identifier for each participant	Integer
DSuse	Dietary supplement use	
DSQTCALC	Calcium intake (mg/d) from DS	Numeric variable Missing data = the participant does not have any calcium intake from supplements.

Figure 3: Screenshot of the DS dataset



4.2. Steps to analyze example 1 using the SIMPLE macro

simple_macro_example1.sas is the SAS code to carry out descriptive analyses for women ≥ 19 years old with NHANES 2011-2014. We broke down the descriptive code into several steps to help the reader understand the procedures involved.

4.2.1. Step 1: Cleaning the SAS environment and loading the macros

Users should open the SIMPLE program in a new SAS session. The first steps in the macro are needed to clean the SAS environment, change system settings, and load the appropriate macros (**Fig. 4**). After running the SAS code, users should also check the SAS log to make sure the step 1 is complete successfully (**Fig. 5**).

Figure 4: SAS code and explanation of cleaning the SAS environment and load appropriate macros.

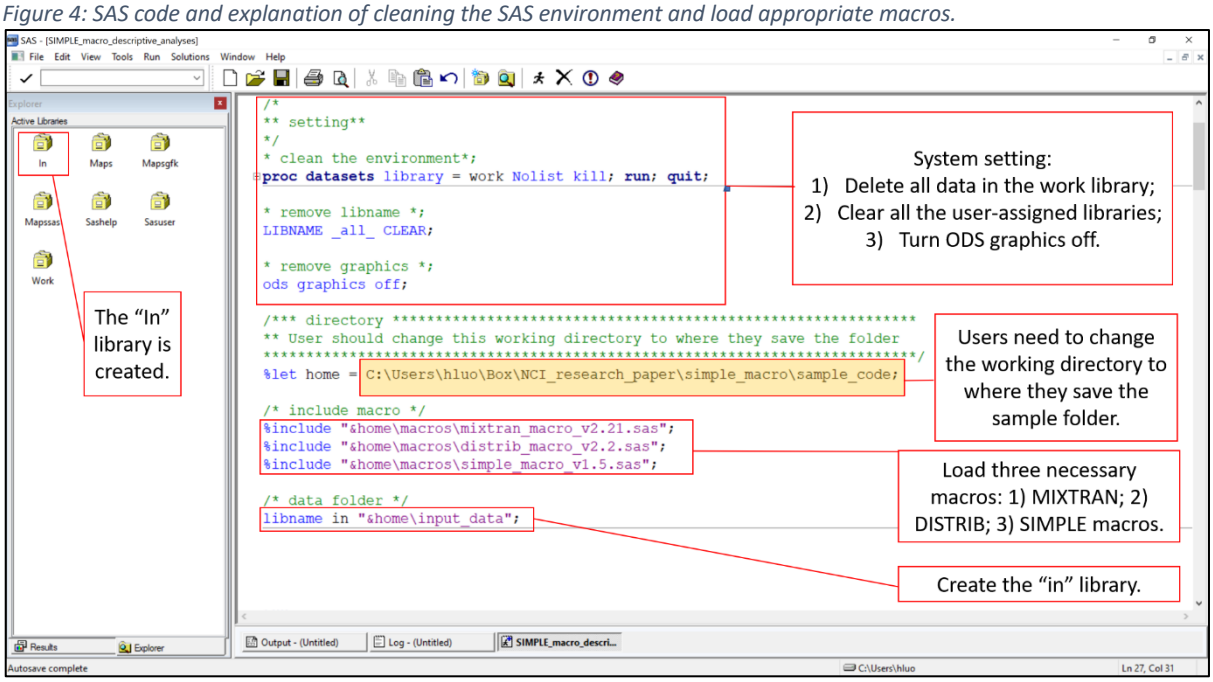
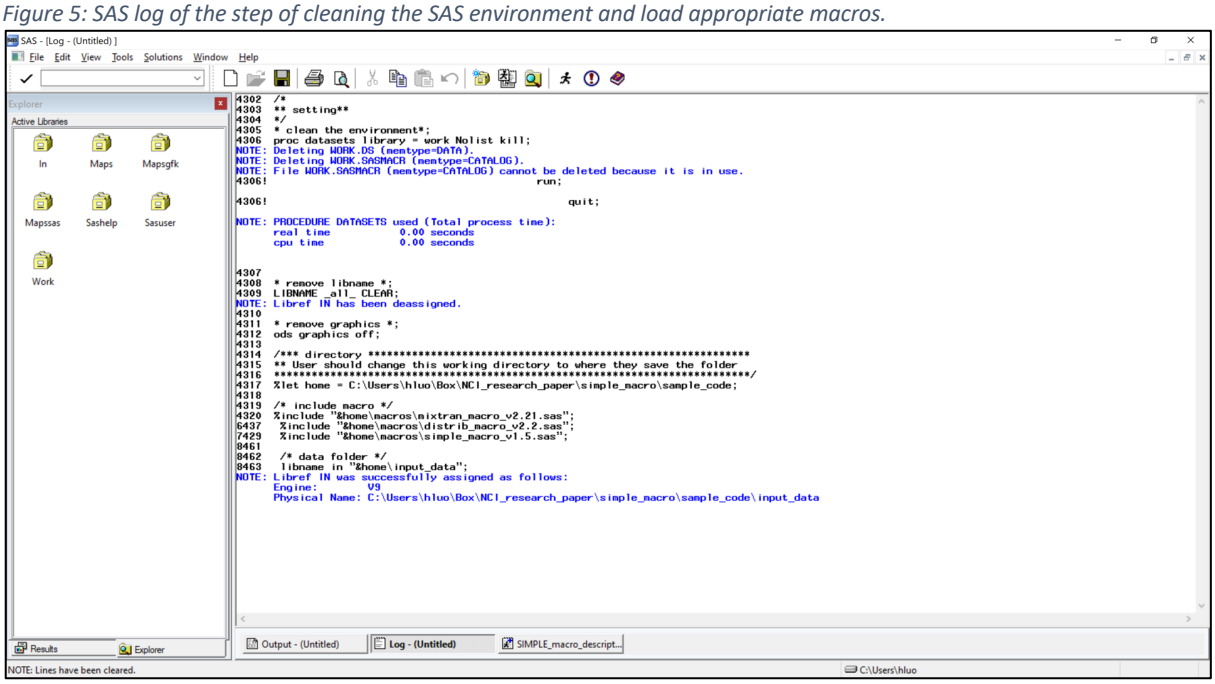


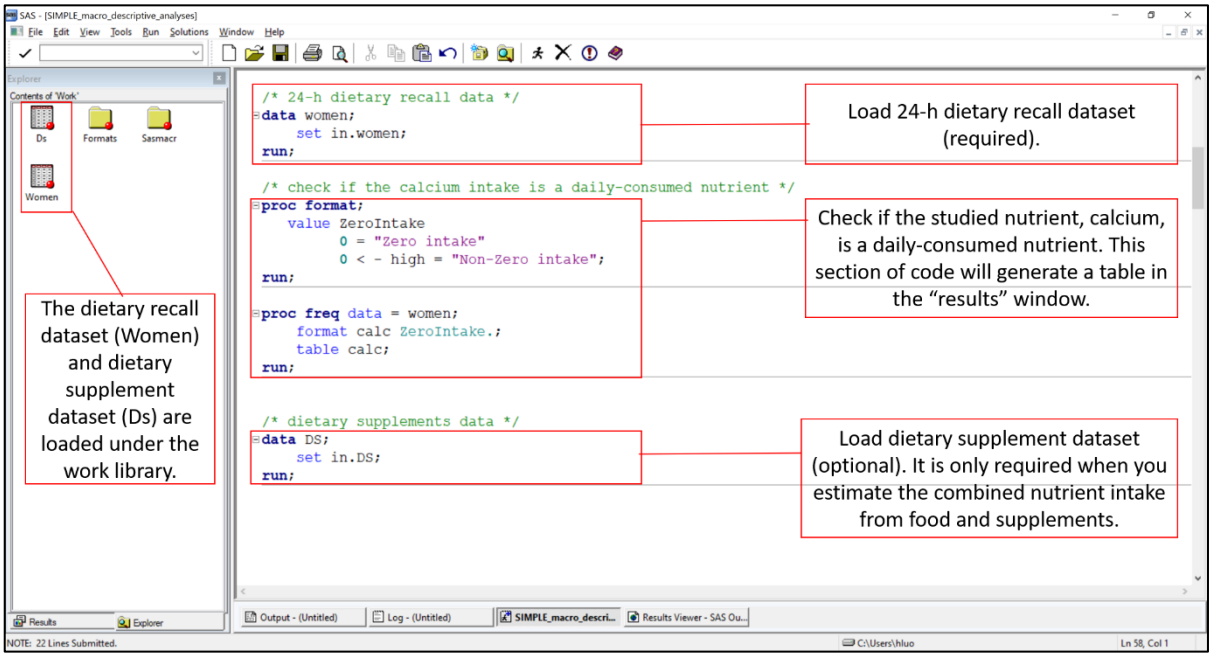
Figure 5: SAS log of the step of cleaning the SAS environment and load appropriate macros.



4.2.2. Step 2: Load 24HR and DS datasets and check if the studied nutrient is nearly-daily consumed.

Users need to load the 24HR dataset (required) and DS dataset (optional). Users also need to check if the studied nutrient is consumed nearly-daily. A nutrient is considered consumed nearly-daily if the percentage of days with zero intake is less than 5% across all participant days (**Fig. 6**) (6). If your nutrient of interest is not consumed nearly-daily, the SIMPLE macro will automatically stop as it does not fit the SIMPLE macro's requirement.

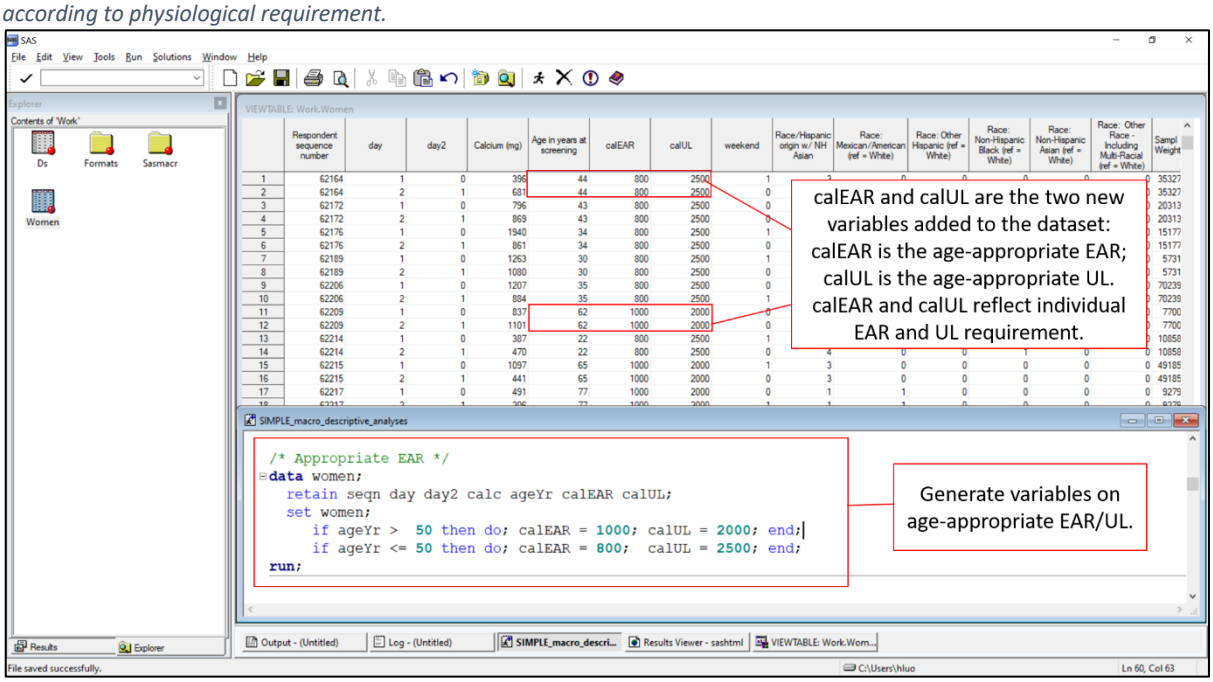
Figure 6: SAS code and explanation of loading 24HR and DS datasets and checking if the studied nutrient is nearly-daily consumed.



4.2.3. Step 3: generate EAR and UL according to physiological requirement.

It is unlikely that all the observations in a dietary dataset have the same EAR and UL cutoffs due to differences in nutrient requirements between subgroups of participants. For example, children at different stages of growth or women in different stages of pregnancy or lactation have different nutrition needs. The SIMPLE macro helps researchers carry out analyses correctly and efficiently by allowing users to specify an EAR or UL for each participant and then generate the population prevalence of inadequacy and excessive intake accordingly. Users need to create variables that specify an EAR or UL value for each participant within the 24HR dataset (**Fig. 7**). Estimating nutrient intake from a single EAR/UL cutoff is provided in **example 1.1** for demonstration purposes; it is always recommended to use individual-specific EAR/UL.

Figure 7: Code and explanation of generating Estimated Average Requirement (EAR) and Tolerable Upper Intake Level (UL) according to physiological requirement.



4.2.4. Step 4: input parameters for the SIMPLE macro and run the SIMPLE macro

The complete inputs of the SIMPLE macro are summarized in **table 3.** All binary variables need to be coded 0 and 1. **Fig 8** shows the application of the SIMPLE macro to estimate calcium intake from food and supplement intake combined using age-appropriate EAR and UL cutoffs (**Example 1.3**), and an explanation for each input parameter of the SIMPLE macro is in green.

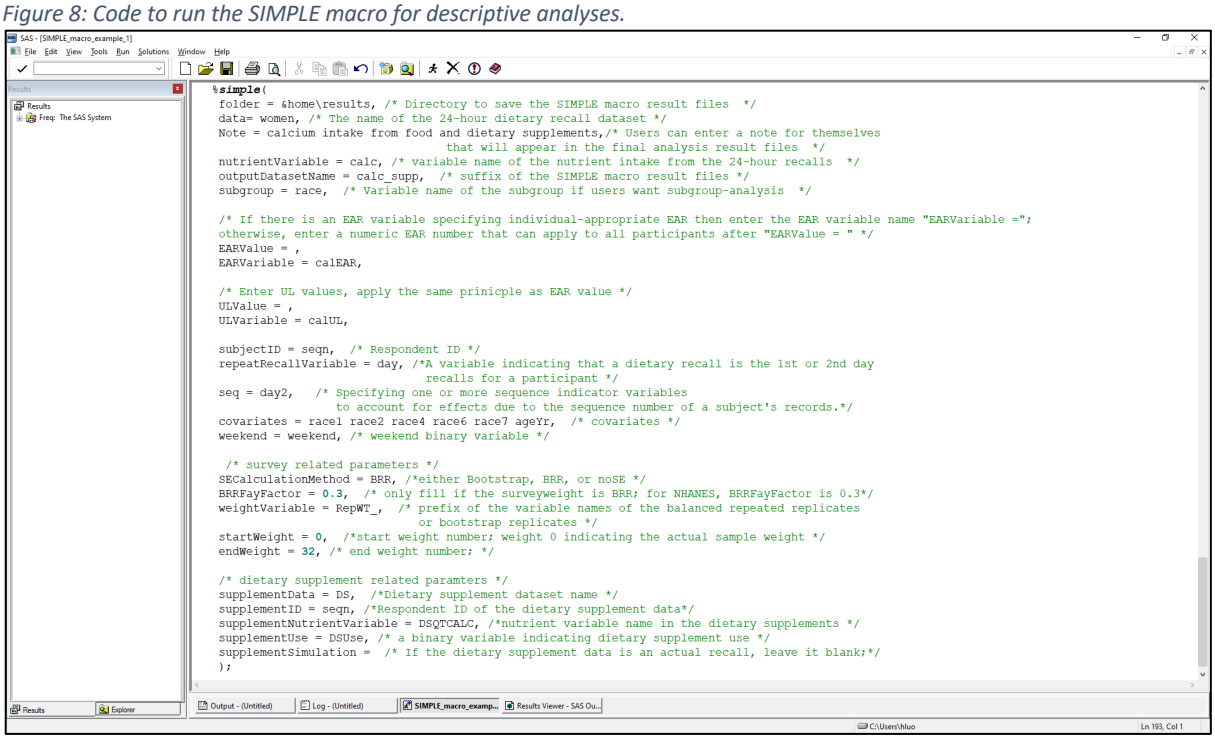
Table 3: SIMPLE macro inputs

Macro parameters	Required or optional	Description
Folder	Required	Directory to save the SIMPLE macro result files.
Data	Required	The name of the 24HR dataset.
Note	Optional	Users can enter a note for themselves that will appear in the final SAS dataset and excel spreadsheet.
nutrientVariable	Required	Variable name of the nutrient intake from the 24HR
outputDatasetName	Required	The suffix of the SIMPLE macro result files
Subgroup	Optional	Variable name of the subgroup if users want subgroup-analysis. The subgroup variable must be either categorical or binary and be in the numeric format.
EARValue	Optional	If all participants in the dataset have the same EAR value, enter a numeric EAR value, such as “800”. **Note: User cannot enter parameters for EARValue and EARVariable at the same time.**
EARVariable	Optional	If there is an EAR variable specifying individual-appropriate EAR, enter the EAR variable name.

		Note: User cannot enter parameters for EARValue and EARVariable at the same time.
ULValue	Optional	If all participants in the dataset have the same UL value, enter a numeric UL value, such as “800”. **Note: User cannot enter parameters for ULValue and ULVariable at the same time.**
ULVariable	Optional	If there is an UL variable specifying individual-appropriate UL, enter the UL variable name. **Note: User cannot enter parameters for ULValue and ULVariable at the same time.**
subjectID	Required	Respondent identifier
RepeatRecallVariable	Required	A variable indicating that a 24HR is the 1st or 2nd or 3rd 24HRs for a participant. This input is a categorical variable
Seq	Optional	Specifies one or more sequence of recall administration indicator variables to account for effects due to the order in which the days of data were collected
Covariates	Optional	Variable names of covariates. **The variable of subgroup analysis must be entered as one of the covariates.** Covariates can be either Binary variable or continuous variable. Categorical variables need to be first converted into multiple binary variables.
Weekend	Optional	Weekend binary variable
SECalculationMethod	Optional	Either Bootstrap, BRR, or noSE
BRRFayFactor	Optional	Only fill in if the survey weight method is BRR. For NHANES, BRRFayFactor is 0.3.
weightVariable	Optional	If users do not want SE, weightVariable should be the actual survey weight variable name. If users want SE, weightVariable will be the prefix of the variable names of the Balanced Repeated Replicates or bootstrap replicates.
startWeight	Optional	The start weight number of the BRR/bootstrap replicates variables.
endWeight	Optional	The end weight number of the BRR/bootstrap weight variables.
supplementData	Optional	The name of the Dietary Supplement (DS) dataset.
supplementID	Optional	Respondent ID of the DS dataset. If the DS data is simulated rather than the actual recall data, this variable indicates how information between the simulated DS data and the 24HR data are related.
supplementNutrientVariable	Optional	The variable name of nutrient intake from the DS. **Nutrient intake from the DS cannot have the same variable name as that of the 24HR dataset.**
supplementUSE	Optional	A binary variable indicating DS use. If the DS dataset is the actual recalls, this input is required.
supplementSimulation	Optional	If the DS dataset is the actual recall, users should leave this parameter blank;

		If the DS dataset is simulated, users should enter "Yes".
supplementCoverageVariable	Optional	If the DS dataset is simulated, enter the variable name indicating the supplement coverage.
BreastmilkData	Optional	Name of the breast milk (BM) dataset.
BreastfeedingVariable	Optional	A binary variable indicating if a respondent consumes BM or not. **This variable should be in the 24HR dataset.**
BreastmilkID	Optional	Respondent identifier. If the BM data is simulated rather than the actual recall data, this variable indicates how information between the simulated BM data and the 24HR data are related.
BreastmilkNutrientVariable	Optional	The variable name of the nutrient intake from BM. **Nutrient intake from the BM dataset cannot have the same variable name as that of the 24HR dataset.**
ByBreastfeedingStatus	Optional	Enter Yes if you need results by breastfeeding status

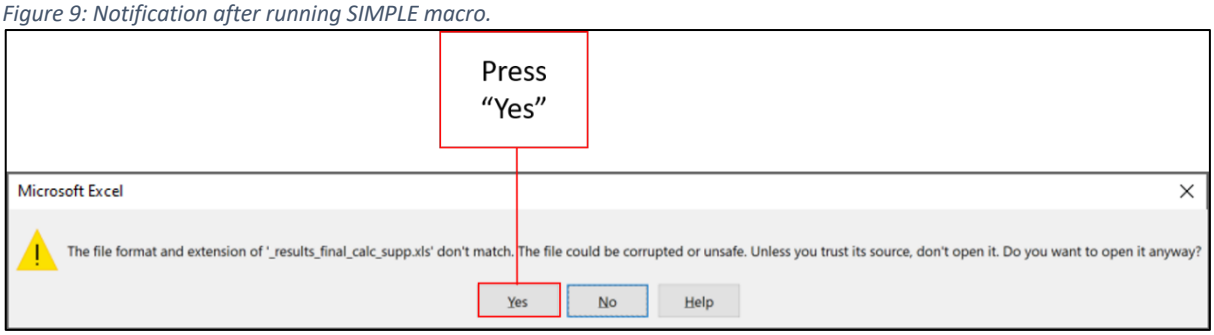
Figure 8: Code to run the SIMPLE macro for descriptive analyses.



4.2.5. Step 5: After a successful run of the SIMPLE macro

After a successful run of the SIMPLE macro, users receive a pop-up notification from Excel requesting permission to open the final results (**Fig 9**). If excel is already open when the macro runs, then users may need to select Excel from their taskbar. Users should press "Yes" to this pop-up notification and then a formatted excel spreadsheet starting with "_final" will be opened automatically (**Fig 9)**. All the outputs of the SIMPLE macro are described in detail in the next section.

Figure 9: Notification after running SIMPLE macro.



4.3. SIMPLE macro outputs

Five output files will be generated and stored in the location specified by users in the SIMPLE macro after a successful run of the SIMPLE macro.

4.3.1. Excel file starting with “_final”.

This file contains the parameters of interest such as sample size, mean, median, 25th and 75th percentile of total nutrient intake, nutrient intake from supplements (if applicable), inadequate intake, excessive intake and their corresponding SEs, and the number of BRR or bootstrap replicates **(Table 4).** The description of this excel spreadsheet is in **table 5**. This is the key result file, and users can copy the results from this file directly to their manuscripts or reports.

Table 4: "_final" excel spreadsheet generated by the SIMPLE macro

note	race	N	mean	mean_SE	supplement_mean	supplement_mean_SE	inadequate_percent	inadequate_percent_SE	excessive_percent	excessive_percent_SE	P_25	P_25_SE	median	median_SE	P_75	P_75_SE	No_replicates
calcium intake from food and dietary supplements	Overall	4110	1071.50	13.67	209.30	0.83	40.06	1.16	4.16	0.41	732.74	10.86	972.94	12.71	1300.79	21.35	32
calcium intake from food and dietary supplements	1	442	1016.92	23.92	89.78	1.15	35.31	2.45	1.02	0.33	754.77	22.31	961.80	22.38	1216.61	29.34	32
calcium intake from food and dietary supplements	2	397	952.74	34.50	128.84	1.80	49.11	2.84	2.53	0.93	668.30	22.32	865.26	25.97	1122.80	38.64	32
calcium intake from food and dietary supplements	3	1659	1145.52	17.98	251.63	1.20	34.67	1.36	5.45	0.59	789.52	13.41	1045.02	17.22	1391.89	27.31	32
calcium intake from food and dietary supplements	4	1024	851.00	17.00	108.78	0.84	60.09	1.96	1.11	0.22	597.33	13.93	779.39	14.96	1018.92	21.23	32
calcium intake from food and dietary supplements	6	471	960.40	26.05	214.64	2.09	49.84	2.83	2.48	0.69	637.83	21.33	858.62	27.95	1180.23	34.98	32
calcium intake from food and dietary supplements	7	117	900.61	70.16	148.93	4.39	55.64	7.98	2.60	1.32	602.22	51.47	794.03	63.06	1055.08	84.43	32

Table 5: Description of the "_final" excel spreadsheet and SAS file generated by the SIMPLE, SIMPLE-Iron, and SIMPLE-1D macros

Variable name	Description
Note	The note that users input in the SIMPLE-macro.
Variable name of subgroup	The variable name of subgroup that users input in the SIMPLE-macro
People	If users want results by breastfeeding status, this variable indicates the breastfeeding status.
N	The number of respondents (not the number of dietary recalls)
mean	Usual mean nutrient intake
mean_se	Standard error of the usual mean nutrient intake
Supplement_mean	The mean nutrient intake from DS (applicable if users input DS information in the SIMPLE, SIMPLE-Iron, and SIMPLE-1D macros)
supplement_mean_se	Standard error of the mean nutrient intake from DS (applicable if users input DS information in the SIMPLE, SIMPLE-Iron, and SIMPLE-1D macros)
inadequate_percent	Prevalence of inadequate intake (applicable if users input EAR information in the SIMPLE or SIMPLE-1D macros or use the SIMPLE-iron macro)
inadequate_percent_se	Standard error of prevalence of inadequate intake (applicable if users input EAR information in the SIMPLE or SIMPLE-1D macros or use the SIMPLE-iron macro)
excessive_percent	Prevalence of excessive intake (applicable if users input UL information in the SIMPLE or SIMPLE-1D macros)
excessive_percent_se	Standard error of prevalence of excessive intake (applicable if users input UL information in the SIMPLE or SIMPLE-1D macros)
p_25	25th percentile of usual nutrient intake
p_25_se	Standard error of the 25th percentile of usual nutrient intake
median	50th percentile of usual nutrient intake
median_se	Standard error of the 50th percentile of usual nutrient intake
p_75	75th percentile of usual nutrient intake
p_75_se	Standard error of the 75th percentile of usual nutrient intake
no_replicates	The number of the BRR or bootstrap replicates.

4.3.2. SAS data file starting with "_final":

SAS data files starting with "_final" have the same contents as the Excel spreadsheet starting with "_final". The SAS data files are saved in case users would like to carry out further analyses with the files. The description of this SAS data file is also in **table 5**.

4.3.3. SAS file starting with "_parameter"

SAS data files starting with "_parameter" have estimated coefficients of covariates, transformation lambda, and values and ratio of within- and between- variance (**Fig 10 and Table 6**). These files provide important information on characteristics of the intake distribution.

Figure 10: "_parameter" SAS file.

	NAME OF FORMER VARIABLE	value	SE
1	A01_INTERCEPT	21.682774696	2.8217344691
2	A02_RACE1	0.3198994801	0.2280172342
3	A03_RACE2	-0.608214393	0.2753059046
4	A04_RACE4	-1.365237219	0.2683967172
5	A05_RACE6	-1.415714387	0.3226237744
6	A06_RACE7	-1.302048013	0.4765219956
7	A07_AGEYR	-0.017109536	0.0053424731
8	A08_DSUSE	0.7955060534	0.1807122868
9	A09_WEEKEND	0.0110468492	0.1136783644
10	A10_DAY2	-0.21652388	0.1048877826
11	A_LAMBDA	0.2995888755	0.030466367
12	Minimum Amount	12	0
13	Between-Person Variance	6.081406258	2.2111506935
14	Within-Person Variance	12.276431105	4.443867743
15	Total Variance	18.357837363	6.5963250045
16	Within- to Between-person Ratio	2.0186829467	0.189416965
17	Within-person to Total variance ratio	0.6687297018	0.0209231609

Table 6: Description of the "_parameter" SAS file generated by the SIMPLE, SIMPLE-Iron, and SIMPLE-1D macros

Variable name	Description
Name	Name of the following variable
• **A01_INTERCEPT**	Intercept of the regression of nutrient intake on covariates
• **Variables start with A02**	Regression coefficients of the covariates
• **A_LAMBDA**	Lambda of Box-Cox transformation
• **Minimum Amount**	The minimum amount of nutrient intake in 24HR
• **Between-person Variance**	Between-person variance value, which varies by different Box-Cox transformation. Users should present this value with lambda value of the Box-Cox transformation.
• **Within-Person Variance**	Within-person variance value, which varies by different Box-Cox transformation. Users should present this value with lambda value of the Box-Cox transformation.

• **Total Variance**	Total variance value, which varies by different Box-Cox transformation. Users should present this value with lambda value of the Box-Cox transformation.
• **Within-to Between-person ratio**	The ratio of within- to between-person variance
• **With-person to Total variance ratio**	The ratio of within-person to total variance
Value	Value of these variables
SE	BRR or bootstrap standard errors of values.

4.3.4. Zipped file starting with "_mcsimData":

Files in the zipped folder "_mcsimData" contain the Monte Carlo dataset using the sample survey start weight. This file is zipped due to the large file size. Interested users can use the nutrient intake variable for pseudo-individuals "mc_t" and the survey weight variable "mcsim_wt" to plot the usual nutrient distribution or perform further analyses. The description of the "_mcsimData" SAS file is in **Table 7**.

Table 7: Description of the "_mcsimData" SAS file generated by the SIMPLE, SIMPLE-Iron, and SIMPLE-1D macros

Variable name	Description
SubjectID from users' input	Respondent identifier
Mcsim_wt	Survey weight of pseudo-persons
Numsims	The number of pseudo-persons simulated per respondent
Mc_t	Usual nutrient intake for pseudo-persons
mc_a	Same as mc_t; usual nutrient intake for pseudo-persons
The _mcsimData also include other variables are based on users' input, such as covariates and subgroup.	

4.3.5. SAS file starting with "_int":

SAS files starting with "_results" have the results of each BRR repeated run or bootstrap iteration. These SAS files are saved here for advanced users to carry out any exploratory analyses with the files. The description of "_int" SAS file is in **Table 8**.

Table 8: Description of the "_int" excel spreadsheet and SAS file generated by the SIMPLE, SIMPLE-Iron, and SIMPLE-1D macros

Variable name	Description
Note	The note that users input in the SIMPLE-macro.
Variable name of subgroup	The variable name of subgroup that users input in the SIMPLE-macro
name	Name of the following variables
• **mean**	Usual mean nutrient intake

• **inadequate_percent**	Prevalence of inadequate intake (applicable if users input EAR information in the SIMPLE or SIMPLE-1D macros or use the SIMPLE-iron macro)
• **excessive_percent**	Prevalence of excessive intake (applicable if users input UL information in the SIMPLE or SIMPLE-1D macros)
• **p_25**	25th percentile of usual nutrient intake
• **median**	50th percentile of usual nutrient intake
• **p_75**	75th percentile of usual nutrient intake
Weight from start weight to end weight	Values of the original survey weight or Bootstrap or BRR replicate (if applicable)

5. Example 2: Descriptive analysis using the full probability method using NHANES 2011-2014

This example uses data on children and teenagers 9 – 18 years old from NHANES 2011-2014 (2). The 24HR and DS dataset of children and teenagers from NHANES 2011-2014 follows the same format as those of women ≥ 19 years old from NHANES 2011-2014 (see the codebooks in **Tables 1 and 2**).

The sample code demonstrates:

- **Example 2.1:** how to estimate the distribution of usual iron intakes from food only and the prevalence of inadequate iron intake using the SIMPLE-Iron macro;
- **Example 2.2:** how to estimate the distribution of usual iron intakes from food and DS and the prevalence of inadequate iron intake using the SIMPLE-Iron macro.

In this example, the SIMPLE-Iron macro applies the full probability method using age- and gender-appropriate reference values to estimate inadequate intake among children and teenagers, for whom the distribution of iron requirements has been defined by the US Institute of Medicine (IOM) (7). The detailed application of the SIMPLE-iron macro to other groups is in **supplementary method 1** in the associated SIMPLE macro paper. The default iron absorption in the SIMPLE-Iron macro is 18%, as suggested by the IOM. However, the SIMPLE-Iron allows users to input their own estimate of iron absorption.

The complete inputs of the SIMPLE-Iron macro are summarized in Table **9**. All binary variables need to be coded 0 and 1. Because the prevalence of inadequate iron intake is estimated using the full probability method, users do not need to specify an EAR value or variable; instead, they will need to enter information regarding gender, age, and Oral Contraceptive (OC) use (if applicable) of the respondents and the macro will automatically apply the IOM distribution.

It's important to note that because the excessive iron intake is estimated using the EAR cut point method, users should use the SIMPLE-macro to estimate the prevalence of excessive intake.

Table 9: SIMPLE-Iron macro inputs

Macro parameters	Required or optional	Description
Folder	Required	Directory to save the SIMPLE macro result files.
Data	Required	The name of the 24HR dataset.
Note	Optional	Users can enter a note for themselves that will appear in the final SAS dataset and excel spreadsheet.
nutrientVariable	Required	Variable name of the nutrient intake from the 24HR
outputDatasetName	Required	The suffix of the SIMPLE macro result files
Subgroup	Optional	Variable name of the subgroup if users want subgroup-analysis. The subgroup variable must be either categorical or binary and be in the numeric format.

subjectID	Required	Respondent identifier
RepeatRecallVariable	Required	A variable indicating that a 24HR is the 1st or 2nd or 3rd 24HRs for a participant. This input is a categorical variable
genderVariable	Required	specify a gender variable for participants: 1 = male; 2 = female
OCUseVariable	Optional	specify an OC USE variable for participants: 1 = OC use; 2 = Non- OC Use; if users leave this parameter blank, SIMPLE-Iron macro assume there is a mixed OC use among women population
ageVariable	Required	specify age (in years)
ironAbsorptionPercent	Optional	iron absorption: from 1% to 100%. If users leave this parameter blank, SIMPLE-Iron macro assume that iron absorption is 18% as recommended by IOM.
Seq	Optional	Specifies one or more sequence of recall administration indicator variables to account for effects due to the order in which the days of data were collected
Covariates	Optional	Variable names of covariates. **The variable of subgroup analysis must be entered as one of the covariates.** Covariates can be either Binary variable or continuous variable. Categorical variables need to be first converted into multiple binary variables.
Weekend	Optional	Weekend binary variable
SECalculationMethod	Optional	Either Bootstrap, BRR, or noSE
BRRFayFactor	Optional	Only fill in if the survey weight method is BRR. For NHANES, BRRFayFactor is 0.3.
weightVariable	Optional	If users do not want SE, weightVariable should be the actual survey weight variable name. If users want SE, weightVariable will be the prefix of the variable names of the Balanced Repeated Replicates or bootstrap replicates.
startWeight	Optional	The start weight number of the BRR/bootstrap replicates variables.
endWeight	Optional	The end weight number of the BRR/bootstrap weight variables.
supplementData	Optional	The name of the Dietary Supplement (DS) dataset.
supplementID	Optional	Respondent identifier in the DS dataset. If the DS data is simulated rather than the actual recall data, this variable indicates how information between the simulated DS data and the 24HR data are related.
supplementNutrientVariable	Optional	The variable name of nutrient intake from the DS. **Nutrient intake from the DS cannot have the same variable name as that of the 24HR dataset.**
supplementUSE	Optional	A binary variable indicating DS use. If the DS dataset is the actual recalls, this input is required.
supplementSimulation	Optional	If the DS dataset is the actual recall, users should leave this parameter blank;

		If the DS dataset is simulated, users should enter "Yes".
supplementCoverageVariable	Optional	If the DS dataset is simulated, enter the variable name indicating the supplement coverage.
BreastmilkData	Optional	Name of the breast milk (BM) dataset.
BreastfeedingVariable	Optional	A binary variable indicating if a respondent consumes BM or not. **This variable should be in the 24HR dataset.**
BreastmilkID	Optional	Respondent identifier. If the BM data is simulated rather than the actual recall data, this variable indicates how information between the simulated BM data and the 24HR data are related.
BreastmilkNutrientVariable	Optional	The variable name of the nutrient intake from BM. **Nutrient intake from the BM dataset cannot have the same variable name as that of the 24HR dataset.**
ByBreastfeedingStatus	Optional	Enter Yes if you need results by breastfeeding status.

6. Example 3: Descriptive analysis and modelling of supplementation and fortification programs using the CNMS

This example uses data from children 1-5 years of age from the CNMS (3). The codebook for the CNMS is in **table 10**.

The sample code demonstrates:

- **Example 3.1**: how to estimate the distribution of usual vitamin A intake from food sources and the associated prevalence of inadequate vitamin A intake using age-specific EAR cutoffs (i.e., for children 1-3 y of age vs 4-5 y of age).
- **Example 3.2**: how to estimate the distribution of usual vitamin A intake and associated prevalence of inadequacy accounting for both complementary food sources and estimated BM consumption. In this example, we do not have individual BM nutrient intake; instead, we have the estimated BM nutrient intake across different zones. In the analysis, we assume breastfed children consume the same amount of BM nutrients within the same zone (**Table 11**).
- **Example 3.3**: how to estimate the distribution of usual vitamin A intake and associated prevalence of inadequacy accounting for food sources, estimated BM consumption, and a simulated dietary supplementation program. In this example, we have the same assumption on BM nutrient intake as the **example 3.2**. We simulate a dietary supplementation program that delivers vitamin A supplements equivalent to 167 µ of absorbed vitamin intake. This vitamin A supplement program could have different coverage and dosage in different zones (**Table 12**).
- **Example 3.4**: how to estimate the distribution of usual vitamin A intake and associated prevalence of inadequacy accounting for food sources, estimated BM consumption, a simulated dietary supplementation program, and a simulated food fortification program. In addition to the estimated nutrient intake from BM and a simulated vitamin A dietary supplementation program, we simulate fortified oil at 12 µ Retinol Activity Equivalent per g of oil.

Users can find the complete inputs of the SIMPLE- macro summarized in **Table 3** under **section 4: example 1**.

Table 10: Codebook of the Cameroon National Micronutrient Survey (CNMS).

Variable	Description	Type
hh	Unique Household identifier The first two digits are the cluster number; the last two digits are the individual household number.	Integer
strata	Two nearby clusters are grouped into one strata.	A total of 45 strata. From 1 to 45
zone	Zone identifier Indicating macro-regions.	Categorical variable 1 = South 2 = North 3 = Yaoundé/Douala
cluster	Cluster number;	Integer

	South (zone 1): cluster no. 31 – 60; North (zone 2): cluster no. 61-90; Yaoundé/Douala (zone 3): cluster no. 1-30.	From 1 to 90
day	Indicating which day of the dietary recalls.	Binary 0 = day 1 1 = day 2
vitaminA	Retinol activity equivalents (µg/d)	Numeric
totaloilgrams	Refined oil intake (g/d)	numeric
Zone	Geographic location	1 = South 2 = North 3 = Yaoundé/Douala
zone2	Created based on variable zone. Indicating if it is North macro-region	1 = North 0 = not North
zone3	Created based on variable zone. Indicating if it is Yaoundé/Douala	1 = Yaoundé/Douala 0 = not Yaoundé/Douala
childsex	Indicating the sex of the child	1 = male 2 = female
Male	Created based on variable childsex. Indicating the sex of the child.	1 = male 0 = female
childAge	Children's age in years	Integer
sqorder	Indicating the sequent order of the dietary recalls.	Binary 0 = day 1 1 = day 2
breastfeeding	Indicating if a participant consumes breast milk	1 = breastfeeding 0 = not breastfeeding or don't know
weekend	Indicating if the dietary recall is taken on a weekend	Binary 0 = not weekend 1 = weekend
RepWt_0	Original survey weight	Integer
RepWt_1-RepWt_48	BRR weights 1 to 48	Integer

Table 11: Estimated vitamin A intake from breast milk

ZoneName (Zone name)	Zone (1 = South; 2 = North; 3 = Yaoundé/Douala [Cities])	Bm_vitaminA (Vitamin A intake from breast milk)
South	1	550.647
North	2	232.227
Cities	3	473.238

Table 12: Simulated Vitamin A supplementation program

zoneName (Zone name)	Zone (1 = South; 2 = North;	supplementCoverageVA	DS_vitaminA

	3 = Yaoundé/Douala [Cities])	(Vitamin A supplement coverage)	(Absorbable vitamin A from dietary supplements)
South	1	0.9	167
North	2	0.9	167
Cities	3	0.9	167

7. Example 4: Descriptive analysis and modelling of supplementation and fortification programs using the CNMS with only a single 24HR per person

This example uses the same dataset as the previous example (3) but demonstrates the application of the SIMPLE-1D macro, using only the first 24HR per person. The example includes the same analysis of vitamin A intake among children 1-5 years of age as shown in **Example 3 (Table 10 to 12)**:

- **Example 4.1**: how to estimate the distribution of usual vitamin A intake from food sources and the associated prevalence of inadequate vitamin A intake using age-specific EAR cutoffs (i.e., for children 1-3 y of age vs 4-5 y of age).
- **Example 3.2**: how to estimate the distribution of usual vitamin A intake and associated prevalence of inadequacy accounting for both complementary food sources and estimated BM consumption.
- **Example 3.3**: how to estimate the distribution of usual vitamin A intake and associated prevalence of inadequacy accounting for food sources, estimated BM consumption, and a simulated dietary supplementation program.
- **Example 3.4**: how to estimate the distribution of usual vitamin A intake and associated prevalence of inadequacy accounting for food sources, estimated BM consumption, a simulated dietary supplementation program, and a simulated food fortification program.

For single-day dietary data, users cannot estimate the ratio of within- and between- person variance components internally (i.e., from the same dataset), as when they analyze dietary data that includes repeated recalls on the same person. Thus, an external variance ratio, defined as a ratio estimated from a similar population from a different study, is often used (6,8). In this example, we used the ratio of within- and between-person variance components of vitamin A intake estimated from Example 3 (i.e., an internal variance components ratio from the same dataset) and, therefore, our results for Example 4 are similar to those of Example 3. However, if the external ratio deviates from the true variance ratio, the resulting usual intake estimates will be biased (6,8); therefore, users should be cautious when applying an external variance ratio to their single-day dietary data and should always conduct sensitivity analyses with a range of external ratios.

The complete inputs of the SIMPLE-1D macro are summarized in **Table 13.**

Table 13: SIMPLE-1D macro inputs

Macro parameters	Required or optional	Description
Folder	Required	Directory to save the SIMPLE macro result files.
Data	Required	The name of the 24HR dataset.
Note	Optional	Users can enter a note for themselves that will appear in the final SAS dataset and excel spreadsheet.
nutrientVariable	Required	Variable name of the nutrient intake from the 24HR
outputDatasetName	Required	The suffix of the SIMPLE macro result files
Subgroup	Optional	Variable name of the subgroup if users want subgroup-analysis. The subgroup variable must be either categorical or binary and be in the numeric format.
EARValue	Optional	If all participants in the dataset have the same EAR value, enter a numeric EAR value, such as “800”. **Note: User cannot enter parameters for EARValue and EARVariable at the same time.**
EARVariable	Optional	If there is an EAR variable specifying individual-appropriate EAR, enter the EAR variable name. **Note: User cannot enter parameters for EARValue and EARVariable at the same time.**
ULValue	Optional	If all participants in the dataset have the same UL value, enter a numeric UL value, such as “800”. **Note: User cannot enter parameters for ULValue and ULVariable at the same time.**
ULVariable	Optional	If there is an UL variable specifying individual-appropriate UL, enter the UL variable name. **Note: User cannot enter parameters for ULValue and ULVariable at the same time.**
subjectID	Required	Respondent identifier
ratioType	Required	"ratioType" Specifies the type of variance ratio. The possible values are "WIVtoTotal": Within-person to total variance. "BIVtoTotal": Between-person to total variance. "WIVtoBIV": Within to Between-person variance
ratio	Required	Ratio value.
Covariates	Optional	Variable names of covariate. **The variable of subgroup analysis must be entered as one of the covariates.** Covariates can be either Binary variable or continuous variable. Categorical variables need to be first converted into multiple binary variables.
Weekend	Optional	Weekend binary variable
SECalculationMethod	Optional	Either Bootstrap, BRR, or noSE
BRRFayFactor	Optional	Only fill in if the survey weight method is BRR. For NHANES, BRRFayFactor is 0.3.
weightVariable	Optional	If users do not want SE, weightVariable should be the actual survey weight variable name.

		If users want SE, weightVariable will be the prefix of the variable names of the Balanced Repeated Replicates or bootstrap replicates.
startWeight	Optional	The start weight number of the BRR/bootstrap replicates variables.
endWeight	Optional	The end weight number of the BRR/bootstrap weight variables.
supplementData	Optional	The name of the Dietary Supplement (DS) dataset.
supplementID	Optional	Respondent identifier in the DS dataset. If the DS data is simulated rather than the actual recall data, this variable indicates how information between the simulated DS data and the 24HR data are related.
supplementNutrientVariable	Optional	The variable name of nutrient intake from the DS. **Nutrient intake from the DS cannot have the same variable name as that of the 24HR dataset.**
supplementUSE	Optional	A binary variable indicating DS use. If the DS dataset is the actual recalls, this input is required.
supplementSimulation	Optional	If the DS dataset is the actual recall, users should leave this parameter blank; If the DS dataset is simulated, users should enter "Yes".
supplementCoverageVariable	Optional	If the DS dataset is simulated, enter the variable name indicating the supplement coverage.
BreastmilkData	Optional	Name of the breast milk (BM) dataset.
BreastfeedingVariable	Optional	A binary variable indicating if a respondent consumes breast milk or not. **This variable should be in the 24HR dataset.**
BreastmilkID	Optional	Respondent identifier. If the BM data is simulated rather than the actual recall data, this variable indicates how information between the simulated BM data and the 24HR data are related.
BreastmilkNutrientVariable	Optional	The variable name of the nutrient intake from breast milk. **Nutrient intake from the BM dataset cannot have the same variable name as that of the 24HR dataset.**
ByBreastfeedingStatus	Optional	Enter Yes if you need results by breastfeeding status.

8. Conclusion

By providing a user-friendly and robust structure around the current core NCI macros, the SIMPLE macro streamlines basic descriptive analyses of 24HR data and provides extra functionality to enable more complex analyses. Specifically, the tool permits users to estimate the observed contributions of supplements or BM to usual nutrient intakes and model the effects of hypothetical nutrition intervention programs, such as supplementation or food fortification. Variations of the tool help to overcome other technical challenges, such as estimating usual intake distributions with only a single day of data per person, and applying the full probability method to estimate inadequate iron intake. This tool has the potential to improve evidence-based nutrition policy and program decisions by decreasing the time and resources required to make high quality dietary analyses available to policymakers and their advisors. We hope this user manual is helpful to users applying the SIMPLE macro and its extensions (SIMPLE-Iron and SIMPLE-1D macros).

9. Reference

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