**Mathematical Appendix**

**Derivation of the equation for diet quality**

Formally, a household’s preference ordering can be characterized by a utility function:

1. $U\left(Fc,z,H\right)$

where **Fc** is a vector of foods consumed, **z** is a vector of nonfoods goods/services, and H is health status. Given a household’s income, total time endowment, market prices, and the opportunity cost of time spent in household production (wages, *w*), utility function (1) is maximized subject to four constraints. The first constraint is the health production function H:

1. H= H($DQ,g, C)$**,**

where $DQ$is a food quality index (i.e., Healthy Eating Index, HEI), a measure of nutritional value of food**, g** is a vector of nonfoods health inputs affecting health, and **C** represents household-specific characteristics which affect the efficiency of producing H from DQ and **g**. The second constraint is the budget constraint

1. I = **F**′ **pF** + **z**′ **pz**,

where **F** is the vector of foods purchased in the market to produce $Fc, $ **pF** is the vector of food prices, **pz** is the vector of nonfoods prices, and I is money income. I is composed of both non-labor (Inw) and labor income Iw which results from the product of wages (w) and work time (tw), thus Iw= w tw and I= Inw + Iw. The third constraint is a time constraint,

1. T = tH + tz + tw,

where T is the total time endowment, tH is the total time producing health, tz is the total time producing/consuming $z$. Finally, the$FQI $input is constrained by the production technology:

1. $DQ$ = h($Fc\left(F, t\_{DQ}\right), C), $

where$ t\_{DQ}$ is the time needed to process **F** into $Fc,$and household characteristics$C$. Note also that equation (5) represents the production technology used to transform market goods (groceries) $F$ into food consumed $Fc$, and food consumed $Fc$ into DQ (i.e., food nutrition). The first order conditions to maximize (1) subject to the three constraints give, among other relationships, an $DQ$ derived demand equation as a function of prices **p**=[ **pF’pz’]’,** wages**,** non-labor Income (Inw), the time needed to process **F** into $DQ ( t\_{DQ})$**,** and household characteristics$C: $

1. $DQ$ = f($p,w, I\_{nw}, t\_{DQ}, C). $

Empirical estimation of (6) is difficult as the complete vector of prices is usually unobserved (in the context of cross-sectional data prices also can be assumed to be constant); thus, one may rely on multi-stage budgeting for the specification of an empirically estimable model.12 In multi-stage budgeting, a consumer allocates time and money in several stages. At a higher stage, they allocate money and time to broad groups of goods. In the context of this study, this means that at a higher stage they might decide how much to spend on food ($ $EF = **F**’**pF** ) and how much time to spend producing $DQ$ ($t\_{DQI}$).