

ABSTRACT

Title of Thesis: THE EXAMINATION OF NATIONAL-NUTRITION POLICIES ON NONCOMMUNICABLE DISEASE MORTALITY AT VARIOUS STAGES OF ECONOMIC DEVELOPMENT: A CROSS-COUNTRY PERSPECTIVE

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The acceleration of economic growth over the past few decades introduces the need to reorient policy to address the needs and challenges for a healthier population. This paper will review the effectiveness of national nutrition policies targeting overweight, healthy diets during pregnancy, infancy and childhood, and noncommunicable diseases (NCDs) across advanced economies and transitional economies. The level of expansion and industrialization of food systems around the world have had a direct impact on nutritional status and health. Considering the magnitude of nationwide public health responses to shifts in mortality have varied over time, this introduces the need to assess the ability for dietary-related policies to successfully reduce NCDs. Results from this analysis can provide a strong rationale as to when interventions will be most effective as well as ways in which we can carry out a timely response in establishing effective policies for countries at different levels of economic development.

THE EXAMINATION OF NATIONAL-NUTRITION POLICIES ON
NONCOMMUNICABLE DISEASE MORTALITY AT VARIOUS
STAGES OF ECONOMIC DEVELOPMENT: A CROSS-COUNTRY
PERSPECTIVE

by

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1. Introduction

There have been considerable advancements in the technological, economic, and social status of countries globally. One of the most influential pieces of this change has been driven by the global scale of interconnectedness through merging economic markets and human activity. Global changes as seen through patterns of human health, international health care, and public health activities (Labonte, 2011) have enhanced the modes through which urbanization and globalization travel, putting more pressure on the flow of information, international migration, trade, and cultural circulation. These rapid changes are also linked to shifts in dietary patterns, activity patterns, and the consequential shift in the leading causes of death seen on a global scale.

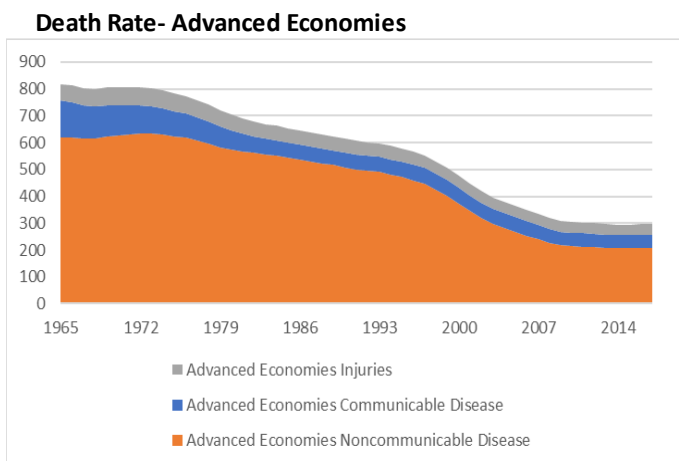
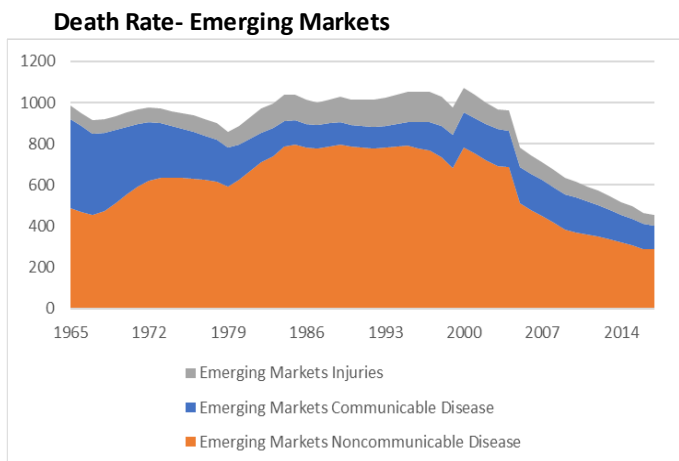
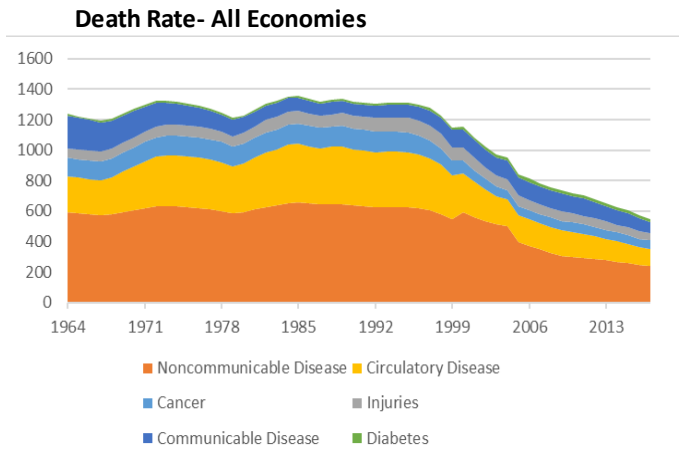
The theory of epidemiological transition stresses the transitional processes across demography, biology, economics, and etiology with ample evidence outlining the determinants and consequences of changing disease patterns (AR, 2005). World Health Organization data, which were used to calculate cause of death ratios, show that noncommunicable diseases contribute to a high proportion of overall mortality followed by a decline in communicable diseases (Figure 1a). The rate of change in disease mortality expression is accelerating across non-advanced economies where the transition to a high energy-dense diet and low activity pattern is becoming more prevalent (Figure 1b). As a result, many countries have adopted a series of resolutions which reflect the high-level commitment to the prevention and control of noncommunicable diseases. Improvements in policy

initiatives, technology, economic growth, expansion in public and private health systems, and an overall reduction in poverty have also contributed to a decline in overall mortality and mortality stemming from infectious diseases.

The strengthening of economic infrastructure has also contributed to the redistribution of wealth and overcoming access inequities, as it relates to food consumption (Rocha D, 2019). Health concerns such as malnutrition are linked to economic development, with economic growth clearly leading to a reduction in malnutrition both across and within countries. For example, Haddad et al found that for every 10% increase in income, malnutrition rates declined by ~5%. Similarly, the percentage of low birthweight births (LBW, 5 births <2.5 kg), among all births, declines as national income rises (Haddad L, 2007). The modernization that low-to-middle income countries (LMICs) have experienced has led to a shift in the high priority public health challenges these regions will face in the next decade. With a decline in mortality from communicable diseases, the share of total morbidity and mortality associated with NCDs such as diabetes, circulatory diseases, and cancer are increasing.

Figure 1: Global Average Death Rates by Economic Development, 1964-2015

Trends in death rates per 100,000, by death type can explain the burden of disease across countries with different income levels.

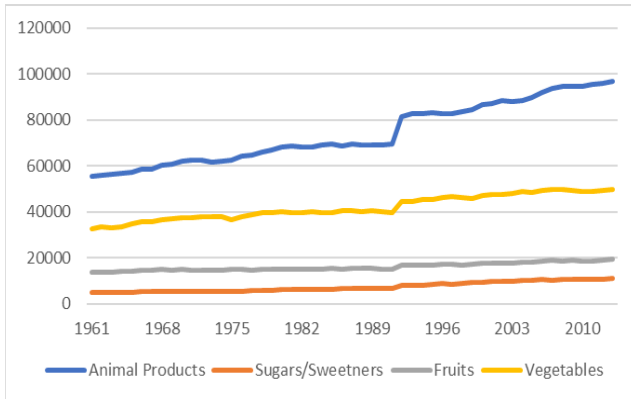


The concept of nutrition transition, which is a globalization-related change, describes a pattern of consumption trends over time. This presents five major shifts in human consumption patterns; hunter gatherer, early agriculture, end of famine, over-eating/ obesity-related diseases, and eventually positive behavior change. Currently, we are facing a global health crisis arising from Pattern 4- Over-nutrition, which has been contributing to rates of premature NCD-related mortality (below the age of 70) (Misra, 2008).

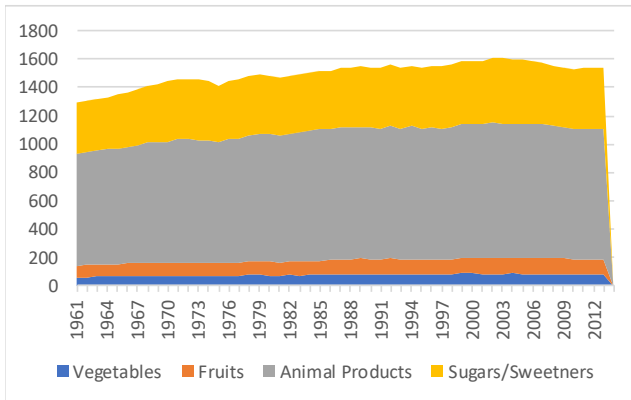
Figure 2: Global Trends in Consumption by Food Group

While overall caloric consumption has increased overtime, the share of total calories consumed in the average diet from animal products and sugar/sweeteners has increased while calories from fruits and vegetables remain low.

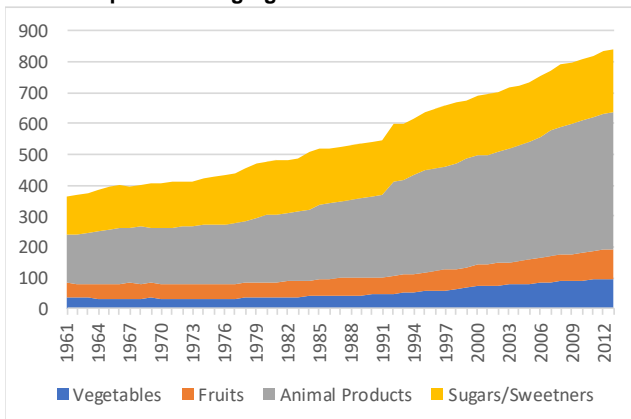
Consumption- All Economies



Consumption- Advanced Economies



Consumption- Emerging Markets

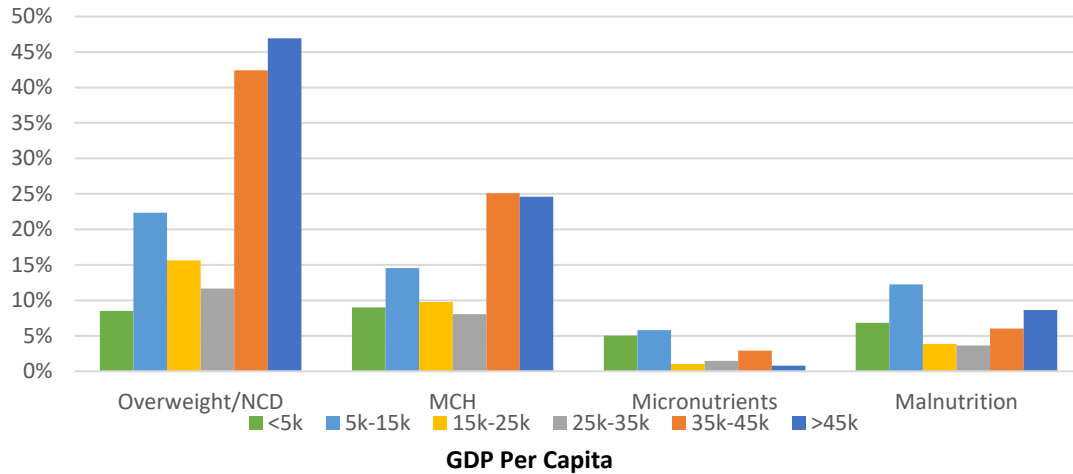


Many emerging markets and developing countries are starting to see a shift in food behavior along with growing NCD prevalence, historically unique to higher income countries (Figure 2). Major global food retailers and manufacturers have begun to place an emphasis on carbohydrates, added sweeteners, edible oils, and animal-source foods and reduced legumes, other vegetables, and fruits (Popkin, 2015). As a result, the share of an individual's diet is increasingly comprised of calorically dense and nutrient deficient foods.

In response to growing rates of obesity and noncommunicable diseases, many advanced economies have begun implementing dietary-related interventions, which include the promotion of fruit and vegetable consumption while reducing an individual's reliance on fats, caloric sweeteners, and animal-source foods (Figure 3). National dietary-related programs in developing countries have traditionally focused on micronutrient deficiency and food security, compared to the rate at which policies targeting maternal, infant, and child (MCH) nutrition strengthening and obesity/NCDs have been implemented across advanced economies (Lim, 2012). Several of the strategies under overweight and NCD policies have been concerned with the reduction of sugar and 'junk' food consumption. These policies have mainly focused on front-of-package (FOP) food profiling and labelling, marketing restrictions, breastfeeding promotion and removal of these foods and beverages from public institutions (S.S. Anand, 2015), (Hawkes, 2007), (J. Jou, 2012). Mexico, France, many of the Western Pacific Islands, Hungary, and Denmark are among countries that have recently passed taxation laws to reduce consumption of these beverages and foods (Biro, 2015), (M.A. Colchero, 2016), (S. Smed, 2016). Rapid changes in the composition of diets in transitional societies are related to a number of socioeconomic and demographic factors. In interpretations of analyses such as these, causality is assumed to run from economic development to improved nutritional outcomes. However, it is important to consider the causality between the establishment of national-level nutrition policies in its ability to improve health outcomes.

Figure 3: Trends in Policy Type across Income Groups

Countries with a higher GDP per capita see a greater likelihood of employing Overweight/NCD and Maternal and Child nutrition policies. Fewer nutrition policies are created across countries with a lower GDP per capita.



This study complements existing evidence by examining the cumulative effectiveness of national-level overweight and NCD policies and/or nutritional interventions at all stages of life to reduce dietary-related mortality across advanced economies and emerging markets over what I establish as their effective lifecycle. Because this examination will provide useful insight as to when nutrition interventions lead to substantial reductions in diet-related mortality, it will be valuable in determining when countries should be integrating them into public health programs and ways to improve its capacity.

2. Research Question

This paper will consider the following – quantification of the cumulative effectiveness of national nutrition policies over time in their ability to reduce the percent share of total deaths that are attributed to NCDs. My assumptions are that

national policies that have been enacted to collectively target non-communicable diseases and maternal, child, and infant nutrition outcomes, will reduce the percent share of mortality from NCDs in the years following across all income groups.

3. Background

3.1. Shifting Policy Priorities

Developing countries have achieved major improvements in overall health status, especially as it pertains to highly infectious diseases. A combination of industrialization and economic growth over the past few decades have contributed to improvements in public health infrastructure and the overall health status of individuals across LMICs, while also contributing to behavior changes reflected in higher income countries. Original publications on the changes in dietary composition over the past few decades contained several key themes: urbanization was a major driving force in global obesity, and overweight and obesity were emerging in LMICs. However, at that point in history, we assumed global hunger and malnutrition were the dominant concerns among developing nations, and it was very difficult to draw attention to the importance of how dietary and physical activity shifts were increasing the threat of obesity in these settings (Popkin B. , 2012). Since growth in GDP has been associated with changes in disease status across both upper- and lower-income countries (Popkin B. , 2006), we can also assume that global economic growth will be associated with shifting policy priorities.

While exploring the current context of nutrition interventions, I saw that efforts have been localized in advanced economies and are scarce across developing countries (Figure 4: likelihood of enacting). There has been limited evidence to

explain why certain countries decide to implement relevant policies at a certain point in time, as it is challenging to assess all the variables in their decision-making process. However, as the world economy continues to strengthen, this shift in disease expression introduces the opportunity to refine policy towards chronic and preventable issues that hold back sustainable health goals.

3.2 Economic Growth Globally

Forces of globalization on food systems have resulted in greater availability and diversity of foods. (United Nations Department of Economic and Social Affairs, 2018). Establishing the capacity for countries to act effectively in this changing environment of access to unhealthy foods and decreased physical activity, requires investment in training of policy-makers and health practitioners and public understanding of the complexities of food production globally. In addition, responses to reducing noncommunicable diseases have varied across countries with different levels of economic development. Awareness of existing efforts have important considerations when trying to maximize each policy's capacity for change.

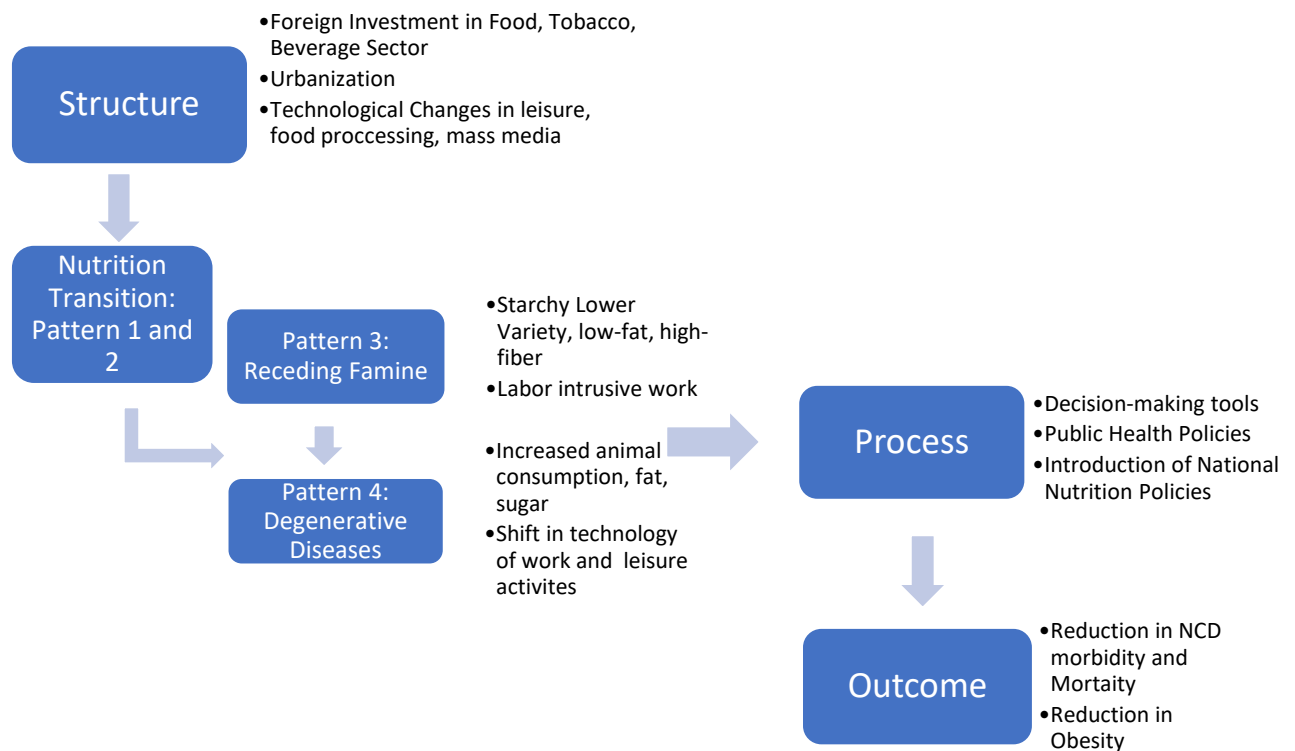
Access and affordability across local food systems have brought about a gradual shift in food culture (towards a more universal one), (FAO, 2016) with consequent changes in dietary consumption patterns and nutritional status that vary with the socio-economic strata (Figure 2). Importantly, the lower socio-economic population groups drift towards poor-quality, energy-dense but cheap and affordable foods, which is apparent when examining the disease trends following the introduction of these foods (Walls H, 2018). While there has been substantial economic growth, large inequalities remain in many LMICs. A challenge for programs and policies is

the need to address food insecurity and hunger without adding to the burden of overweight and obesity. As it relates to our assessment, we will focus on the interventions within each country's healthcare system that seek to address nutritional health at all stages of life, as well as NCDs and obesity, as there are lessons to be learned from large-scale health-related interventions in advanced economies and emerging markets.

4. Research Design and Methods

To analyze the relationship between nutrition policies and health outcomes, a conceptual framework to assess the performance of national nutrition policies in relation to dietary risk factors for NCDs will be utilized. The following framework is adopted from Popkin's (2003) model of nutrition transition, and Donabedian's (1966) management model. It is also informed by the Food and Agriculture Organization's (FAO)'s (2004) model on changes in food systems.

Figure 4: Conceptual Framework



4.1 Data and Methodology

Using a large panel of country-level data, I exploit the large heterogeneity between countries and over time to identify the associations between percent share of deaths from non-communicable diseases and the relevant covariates. The WHO Mortality database provides raw death and population data gathered from national authorities. I convert these data to standardized death rates by cause from 1950 forward. For this paper's time series analysis, I used annual data from 1989 to 2015 covering 92 countries (36 advanced economies and 50 emerging markets). See *appendix for list of countries by income group*.

To estimate stock of policies enacted to target obesity and chronic disease morbidity and mortality, I used the WHO Global database on the Implementation of

Nutrition Action (GINA) for information on the nutrition policies and actions in countries. GINA provides data on 2,158 nutrition policy changes enacted by 198 countries around the world over the last several decades. In order to transform this qualitative database, I have coded the policy measures according to the policy area and population targeted, as well as implementation start and end date (if it exists). My policy dataset assesses for each policy measure whether it represents the start year (coded +1) or end year (coded -1) within the existing public health system. This quantitative dataset has been personally compiled and coded using qualitative data from WHO and is a unique addition to the literature in its own right (see section 4.3 for more details on the creation of this dataset). My model will include the following policies: Overweight/NCDs/MCH, Micronutrient deficiencies, and Malnutrition. For the purpose of this analysis, it was necessary to combine the NCD policy stock variable and the stock of MCH policies to avoid biasing our results because a multicollinearity issue existed after conducting a robustness check.

4.2 Data sources used

Dependent Variable

To determine percent of deaths by NCDs, I utilized the WHO Mortality Database containing data from 1950 to date. This is a compilation of mortality data by age, sex, and cause of death coded according to ICD codes. Data prior to 1979 (ICD-7 and ICD-8) have been self-concorded to ICD-9 and ICD-10 indicators. Non-communicable disease mortality in this study is defined as: percentage of total death attributed to, heart disease, hypertension, cancer, diabetes. Mortality rates in this database were age and sex adjusted using 2010 UN population weights (see

Appendix for details). Because data from the WHO Mortality Database contained death rates in its raw form, it was necessary to remove outliers by winsorizing the data to exclude the upper and lower 2.5 percentiles. Percent of NCD deaths is simply calculated as:

Percent Share Equation (1)

$$\% \text{ share NCD deaths} = \left(\frac{\text{NCD Death Rate}}{\text{Total Death Rate}} \right) \times 100$$

Independent Variables

Data on the implementation of national-level nutrition policies and interventions have been provided by WHO's Global database on the Implementation of Nutrition Action (GINA). This database summarizes all nutrition related policies and actions by country. For the purpose of this study, the policies for analysis will be categorized into the following themes: (1) overweight and diet-related NCD, (2) maternal, infant and child nutrition (MCH), (3) vitamins and other micronutrients, (4) acute malnutrition. In my model, I have chosen to combine MCH stock of policies with our overweight/NCD stock. After conducting a multicollinearity test, I found that it was highly correlated to my overweight and NCD stock variable; this would have ultimately biased my results if I had left it in the model as its own unique variable or had removed it entirely. A reason for this overlap between the two policies could have been due to comprehensive interventions a country employed when establishing a public health intervention eventually covering both populations. Similarities in implementation are also demonstrated in Figure 4. See *appendix for methodology*. To assess population and demographic patterns of these countries,

the United Nations database supplies the annual total population and annual urban population from 1950-2050 (projection). Data on life expectancy for all countries in our ~50-year period has been provided from the World Bank. Gross Domestic Product (GDP) per capita (Purchasing power parity; 2010 international dollars) to determine income-levels for all countries has been provided by the World Bank and will be log-transformed. Data on education, or average years of total education ages 15+, has been provided by World Bank (Barro-Lee database).

4.3 Nutrition Policy Dataset Creation

The creation of the nutrition policy variables is informed by WHO's annual policy reviews, routine policy monitoring activities, and regional partner databases under the Global database on the Implementation of Nutrition Action (GINA). GINA is a repository of policies, actions, and mechanisms related to nutrition. This includes: (1) overweight and diet-related NCD, (2) maternal, infant and child nutrition, (3) vitamins and other micronutrients, and (4) acute malnutrition. While this database contains national-level policies available for 198 countries, with 2158 policies published since 1970, onward, reporting of policies was inconsistent and somewhat unreliable for many LMICs prior to the late 1980s. For this reason, my model only assessed values from 1989 onward.

When developing the nutrition policy variables, I began by aggregating a list of total nutrition policies implemented as of 1970 for every available country. Each policy contained a detailed list of what interventions it was aimed at (called *topics*) as well as the start date and end date (if known). I categorize all the policies into four high-level nutritional themes based on their topics.

To translate these policies into panel data fit for quantitative analysis, each time a policy began its respective high-level theme was given a (+1) and each time a policy ended it was given a (-1). A (0) was given if a policy neither ended nor began. That is, annual flow data of policies represents the net gain (loss) of policies for each specific theme. Stock of policies in year t is therefore calculated as stock ($t-1$) + flow (t) – beginning with a stock of zero in year 1970 (start of database). This quantification allowed me to analyze the size of a country’s nutrition policy framework as well as the effects of changes to the existing policy framework on their desired outcomes. My regression utilized stock of policies under each topic to indicate trends in policy implementation. For the primary assessment, a lag of 5-years will be applied to *Vitamins and Micronutrient Deficiencies* and *Acute Malnutrition* policies to allow for intervention effects to be observable.

See appendix for methodology.

4.4 Econometric Methodology

The analysis utilized panel econometric techniques, mainly country and time fixed effects. By including country fixed effects (group dummies), for a cross-country analysis over my specified time-period, I am controlled for the average time-invariant differences across countries in any observable or unobservable predictors, such as differences in quality of food, sophistication, availability, etc. The fixed effect coefficients will take into consideration all the *between*-country action, leaving only *within*-country action. In addition to country fixed effects, the use of time fixed effects will control for all cross-sectional invariant trends over time. The combination of these controls reduced the threat of omitted variable bias. While this analysis

began by utilizing policy data starting from the 1970s, due the lack of accuracy and inconsistent reporting of each policy that was implemented, it was necessary to utilize data from 1989 onward and exclude data prior to that. The analysis adds to the literature by using macro data and quantitative policy data from a large variety of countries and time periods to address policy questions that have been addressed almost exclusively by micro data and qualitative survey techniques until this point.

4.4.1 Statistical Analysis

All analyses were conducted in Stata 14. This purpose of this analysis was to derive cumulative policy effects over a 7-year period. In addition, it was necessary to include a time trend to the regression model to account for policy effects over time--*Refer to appendix table 5 for optimal lag length*. This analysis utilized clustered standard errors to control for heteroskedasticity.

I opted against using standard OLS errors or even robust standard errors because they require independent observations across independent variables. Therefore, errors can be correlated within clusters.

4.4.2 Adjusting for Impact and Long-Run Effect

In order to derive policy effectiveness estimates, adjustments were made so the long-run impact of policies can be expressed. In this context, an impact analysis looks at the effects of a policy on share of mortality over a period of time. Impact analysis is based on economic multipliers, which will account for the total effect of a policy, after the application of a 7-year lag, considering we care less about capturing the contemporaneous effect of the policies.

This analysis estimates the effect of nutrition policy stock against the percent share of noncommunicable disease mortality. It controls for all differences across countries that are constant over time and shocks that affect all economies. While the potential set of drivers is large, guided by the conceptual framework in *Figure 1*, the analysis focuses on factors that can be measured consistently across countries and over time.

Equation (2): Finite Distributed Lag model

$$y_t = \alpha_0 + \delta_0 NP_t + \delta_1 NP_{t-1} + \delta_2 NP_{t-2} + \delta_3 NP_{t-3} + \delta_4 NP_{t-4} + \delta_5 NP_{t-5} + \delta_6 NP_{t-6} \\ + \delta_7 NP_{t-7} + \beta_1 (Micro_{t-5}) + \beta_2 (Mal_{t-5}) + \beta_3 (GDP) \\ + \beta_4 (Educ) + \beta_5 (LE) + \gamma_c + \gamma_t + u_t$$

where...

$t = 1989, \dots, 2015$

$\gamma_c, \gamma_t =$ country and time fixed effects, respectively

$NP =$ stock of OW, NCD, MCH policies

$Micro =$ stock of micronutrient deficiency policies

$Mal =$ stock of malnutrition policies

$Educ =$ average years of education

$LE =$ life expectancy

$GDP =$ GDP per Capita

$\beta_0 =$ Short run multiplier

$\sum_{i=0}^7 \delta_{t-i} =$ Long run propensity (LRP)

Estimating Coefficient and Standard Error of Long-Run Propensity

While the long run propensity calculated above provides an accurate coefficient, it does not provide relevant standard error values. To estimate the LRP coefficient

with relevant standard errors, I need to transform the model above. There are two steps to do this: (1) write the LRP as

$$(1) \quad \theta = \delta_0 + \delta_1 + \delta_2 + \delta_3 + \delta_4 + \delta_5 + \delta_6 + \delta_7,$$

which implies that

$$(2) \quad \delta_0 = \theta - \delta_1 - \delta_2 - \delta_3 - \delta_4 - \delta_5 - \delta_6 - \delta_7.$$

Estimates for long-run effects are applied to my time-series model to calculate the effectiveness of each stock of policies on its ability to reduce the percent share of NCD-related mortality over the span of 7-years.

My decision on the lag length assumes that the upper bound for the lag length maximizes R^2 .

Then equation (2) becomes:

$$\begin{aligned} Y_t &= \alpha + \delta_0 X_t + \delta_1 X_{t-1} + \delta_2 X_{t-2} + \delta_3 X_{t-3} + \delta_4 X_{t-4} + \delta_5 X_{t-5} + \delta_6 X_{t-6} + \delta_7 X_{t-7} + u_t \\ &= \alpha + (\theta - \delta_1 - \delta_2 - \dots - \delta_7) X_t + \delta_1 X_{t-1} + \delta_2 X_{t-2} + \dots + \delta_7 X_{t-7} + u_t \\ &= \alpha + \theta X_t + \delta_1 (X_{t-1} - X_t) + \delta_2 (X_{t-2} - X_t) + \dots + \delta_7 (X_{t-7} - X_t) + u_t . \end{aligned}$$

The last equation suggests running the transformed regression of Y_t on X_t and $(X_{t-i} - X_t)$ to achieve the LRP coefficient (θ) and its corresponding standard error and confidence interval.

Thus, to calculate the estimated value of LRP along with its standard error as in Eq(2), I generated the values of:

$$(NP_{t-1} - NP_t) \text{ and } (NP_{t-2} - NP_t) \dots (NP_{t-7} - NP_t)$$

I follow by regressing y_t against the differences in my lags for advanced economies, emerging markets, and overall population to estimate the model:

Equation (3): Transformed Long-Run Propensity

$$\begin{aligned}
y_t = & \alpha_0 + \theta NP_t \\
& + \delta_1(NP_{t-1} - NP_t) + \delta_2(NP_{t-2} - NP_t) + \delta_3(NP_{t-3} - NP_t) + \delta_4(NP_{t-4} \\
& - NP_t) + \delta_5(NP_{t-5} - NP_t) + \delta_6(NP_{t-6} - NP_t) + \delta_7(NP_{t-7} - NP_t) \\
& + \beta_1(Micro_{t-5}) + \beta_2(Mal_{t-5}) + \beta_3(GDP) \\
& + \beta_4(Educ) + \beta_5(LE) + \gamma_c + \gamma_t + u_t
\end{aligned}$$

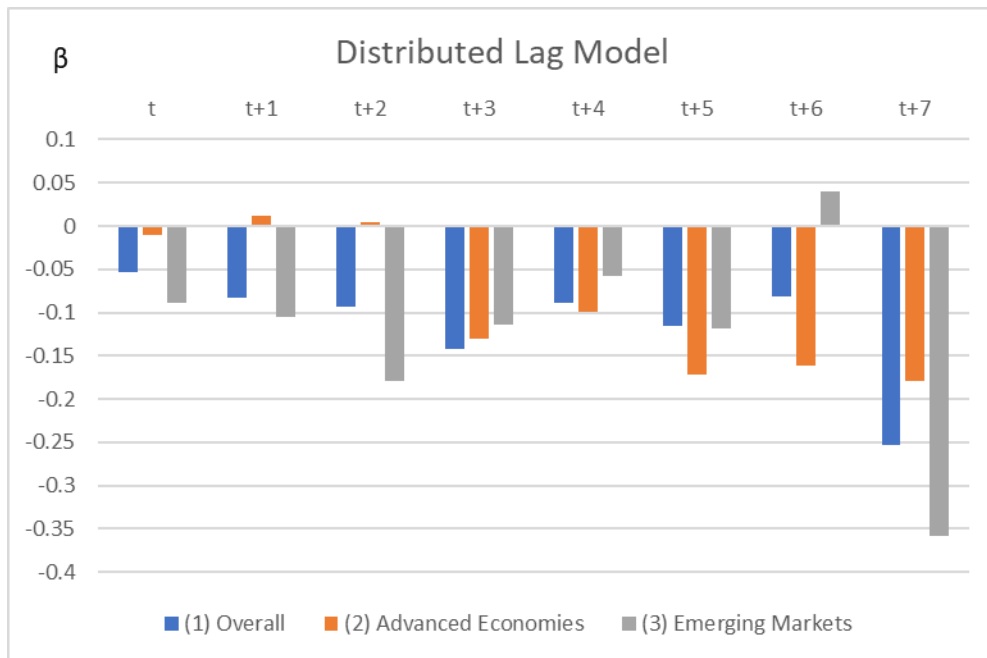
5. Results

5.1 Summary of Regression Results

Table 1 provides the regression results of the original model (non-transformed) for 92 countries that were ultimately included in the model and estimates broken into each income group in question. For each independent variable, the table lists the regression estimates using a fixed effects OLS model. Table 2 presents the results for the LRP estimated using the transformed model. The outcomes of the long-run cumulative multiplier in Table 2, provide the most relevant computation for analysis – the long-term impact of nutrition policies on noncommunicable disease mortality. Following a cumulation of 7 years of lags of the stock of overweight and NCD (and MCH), there were significant reductions in the percent share of mortality across all income groups ($p < 0.05$). Results from emerging market countries yielded a greater decrease in mortality following the initiation of a policy targeting overweight and NCDs (and MCH). That is, the cumulative effect of the NCD and/or MCH policies resulted in a there was a 0.359 percent decrease in the share of deaths from noncommunicable diseases ($p < 0.05$). Likewise, advanced economies saw a cumulative decline of 0.179 percent 7 years post-implementation, although results were not significant. Figure 5 displays the 7-year cumulative effect of

overweight/NCD, and MCH policies (x) on the ability to reduce the percent share of NCD related mortality (y). This pattern of dynamic marginal effects and cumulative effects tell us some insight on the magnitude and timing of the effect of x on y.

Figure 5: Cumulative Effects of x on y



The coefficients for the additional covariates, such as GDP per capita, life expectancy, urbanization was consistent with the literature, although results were not statistically significant. For emerging economies, the establishment of NCD and/or MCH policies were effective in reducing the share of mortality. The analysis confirms that the effects of an increase in policies targeting NCDs across all income groups were effectively driven by emerging markets. Table 1 also estimates the short-run multiplier, which is the contemporaneous effect of x on y. This yielded a 0.0885 percent decline in NCD mortality among emerging markets, and a 0.0658 percent decline among both advanced and emerging economies— roughly a 0.3 and

0.2 percent difference, respectively. Taken at face value, the contemporaneous effect is only about 10% of the cumulative effect. Understanding that policy effects were increasingly visible over time compared to its immediate effect is reflective of variations in implementation and uptake of interventions across all economies.

Table 1. Short-run Multiplier: Percent NCD-related Mortality ¹

VARIABLES	Overall	Advanced Economies	Emerging Markets
Impact Multiplier: Overweight/NCD and MCH Policies			
	-0.0658	-0.0106	-0.0885
	-0.0608	-0.0772	-0.0756
1- year Lag Stock of Overweight/NCD and MCH Policies	-0.0287	0.023	-0.017
	-0.0364	-0.0565	-0.0715
2- year Lag Stock of Overweight/NCD and MCH Policies	-0.0117	-0.00768	-0.0737
	-0.0429	-0.041	-0.0833
3- year Lag Stock of Overweight/NCD and MCH Policies	-0.0481	-0.135**	0.0652
	-0.0443	-0.0658	-0.0696
4- year Lag Stock of Overweight/NCD and MCH Policies	0.0539	0.0315	0.0567
	-0.0501	-0.0548	-0.1
5- year Lag Stock of Overweight/NCD and MCH Policies	-0.0279	-0.0727	-0.0607
	-0.0569	-0.0862	-0.123
6- year Lag Stock of Overweight/NCD and MCH Policies	0.0344	0.0097	0.158*
	-0.0515	-0.0727	-0.0929
7- year Lag Stock of Overweight/NCD and MCH Policies	-0.171*	-0.018	-0.399***
	-0.0944	-0.137	-0.143
5- year lag of Stock Vitamins and other micronutrients policies	0.241	1.096	0.256
	-0.275	-0.786	-0.308
5- year lag of Stock Acute Malnutrition policies	-0.459**	-0.895**	-0.409*
	-0.194	-0.395	-0.22
Percent Urban Population	0.0317	0.153	-0.148
	-0.12	-0.152	-0.22
Log-Transformed Average Years of School	5.668***	5.417**	4.995**
	-1.321	-2.028	-2.136
Life Expectancy	-0.362	-0.266	0.174
	-0.377	-0.419	-0.604
Log-Transformed GDP per Capita	-1.044	-2.909	-0.625
	-1.916	-2.227	-2.91
Constant	8.759	12.48	-16.18
	-29.66	-33.92	-48.64
Observations	1542	770	677
R-squared	0.424	0.525	0.428
Number of ifscodes	92	36	50
Country FE	YES	YES	YES
Year FE	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Study calculations

Note: The table presents the impact multiplier from the estimation of equation (2) for the share of mortality for each income group of countries on a sample of 36 advanced economies and 50 emerging market countries during 1970–2017 using annual data. See Annex Table 1 for the construction of the explanatory variables and Annex Table 3 for the countries in the sample. All specifications include country and year fixed effects. Standard errors are in parentheses. AE = advanced economies EM= emerging markets.

Table 2. Seven-year Cumulative Policy Effect on the Percent Share of NCD-related Mortality ²

Equilibrium Multiplier	Dependent Var: % share NCD death**		
	(1) Overall	(2) Advanced Economies	(3) Emerging Markets
LRP over 7-year period: Overweight/NCD and MCH Policies	-0.265** (-0.11)	-0.179 (-0.199)	-0.359** (-0.147)

6. Discussion

Results from the analysis demonstrated that progress was uneven across countries. Results from the long run cumulative effect of the joint NCD and MCH policies found that emerging markets yielded a greater reduction in percent share of NCD-related mortality. The impact analysis of the policies could indicate a major reduction in mortality, speaking to its effectiveness overtime. Examination of the current state of public health infrastructure across economies can help explain these differences in results. Possible gaps in implementation could have been due to inadequate funding of preventative efforts, inadequate action across different sectors within and outside the health system; and a lack of standardized monitoring and evaluation mechanisms to inform policies. To address implementation gaps, governments need to invest more in effective interventions such as the WHO-recommended best-buy interventions, improve action across different sectors, and enhance capacity in monitoring and evaluation and in research. In public health, the concept of “upstream” and “downstream” factors describes how social determinants

Source: Study calculations

Note: The table presents the cumulative effect of our policy variable over a 7-year period. This estimation is derived from our transformed model in equation (6). See Annex section 3 to see how lag lengths were derived. AE = advanced economies EM= emerging markets. *p < .10; **p < .05; ***p < .01.

of health and preventative efforts ultimately go on to influence health outcomes (Taylor K, 2010). Currently, much of the policy focus around improving population health status in advanced economies tend to focus on medical advancements and integrating technology in targeting the individual level factors that contribute to illnesses. This focus on the medical determinants of health across advanced economies can help to explain why preventative policy efforts are not as effective, and why they may take longer to see results. Whereas countries that have fast growing average incomes, such as emerging markets, can now develop their health care infrastructure to prioritize prevention, especially regarding nutrition and healthy eating behaviors (D Williams, 2012). It would be useful to identify additional characteristics among emerging markets, that can explain why policies are successfully meeting its goals, while advanced economies are not.

6.1 Study strengths and limitations

Overall, the results indicated that the LRP over 7-years presented a reliable measure showing the cumulative effect of established policies. All measures except for advanced economies demonstrated statistical significance ($p > 0.05$). This analysis utilized a comprehensive dataset in which it applied econometric methods to allow for multiple robustness checks when testing the association between the dependent and independent variables. In addition, this assessment utilized a unique dataset which allowed me to compile and code nutrition policy implementation and end dates to determine each country's policy framework at each point in time. Despite the strengths of this study, this paper is subject to limitations. Considering this study utilizes data from a variety of sources across a ~50-year period, the

databases are prone to missing data which initially led to an unbalanced panel of data. For example, data on average years of education were only available in five-year increments. However, this was remediated by linearly interpolating values in STATA to fill in gaps. Due to country-specific resource constraints, some data may have levels of inaccuracy or have not been reported and are therefore estimates generated by reporting entities – although fixed effects should at least partially absorb this variation. In this case, while policy data was available for some countries starting in 1970 onward, the accuracy and balanced reporting across countries were extremely varied. As a result, our model utilized policy data from 1989 onward to allow for the most accurate data to be analyzed within our study. Another limitation of this model is that aggregated country data may mask variations in individual-level behaviors.

6.2 Public Health Significance

Global consumption behavior and other lifestyle activities have changed drastically over the past several decades. By the 1980s, there was a growing understanding that dietary quality was worsening, and non-communicable diseases were on the rise. However, with this new knowledge that had the potential to drive research, not enough attention was placed on the capacity for different types of nutrition policies to impact NCD mortality across countries with different levels of income, at this level of comprehensiveness. Policies and programs reflect a nations commitment to act in response to a health crisis. However, having a policy in place does not assure that the objective of those policies is met. Poor implementation and unclear policy objectives interfere with the success of a policy. Up until now, there

have only been qualitative assessments which review nutrition policies globally (WHO, 2010). Yet, uncertainty around what the best stage is for nutrition policies to be implemented and when it will be the most effective has hindered public health progress. Countries undergoing developmental changes (from nutritional deficiencies to overnutrition) will find this evidence especially useful.

Research supports that people in emerging market and developing economies are at an increased risk of obesity and development of diseases. There is growing evidence that those generations who experienced famine and malnutrition early on in life were more likely to have children with higher adiposity (Popkin B. , 2012). This highlights the importance of nutritional environments that result from nutrition transition, and its impact on long term health. For example, gestational diabetes is related to offspring body composition and increased risk of insulin resistance and diabetes in the offspring. Therefore, there is concern over the intergenerational amplification of diabetes risk (in addition to other illnesses). If a person begins to experience obesity earlier on in life, they are at an increased risk of developing diabetes and other obesity related diseases (Popkin, 2012). Until recently, much of the work done to target obesity and non-communicable disease was centered around economically advanced nations, with a focus on caloric surpluses. These findings can help to inform initiatives to utilize a proactive – not reactive – approach towards policy implementation.

This paper expanded on the current initiatives taken to reduce mortality and applied them in a macro-level setting. To ensure the sustainability of evidence-based policies, it is important to identify when policies are best implemented, and if

current initiatives are effective in reducing NCD-related mortality. The main takeaway from the results is that we can now determine the capacity at which a targeted NCD nutrition policy will be effective, over a certain time, in reducing mortality. Many countries that decide to implement a high-level nutrition policy which targets obesity and noncommunicable disease risk reduction at all stages of life, can now consider these results when developing and implementing national interventions and ways to realign interventions to meet national goals. As we saw, only considering the immediate effects of a policy results in an underestimation of its cumulative effects to a country. The timely execution of effective policies aimed at sustainable improvements across food systems and nutritional interventions can be a means to measurably improve preventable disease mortality outcomes.

Glossary

- GDP per capita: GDP per capita is defined as “gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2010 U.S. dollars.” Log of GDP per capita will be used to control for income level across countries to reflect percent changes rather than marginal changes in income.
- Urban population: Refers to people living in urban areas as defined by national statistical offices. It is calculated using World Bank population estimates and urban ratios from the United Nations World Urbanization Prospects.
- Nutrition Policies/Programs: Policies enacted to target obesity and chronic disease morbidity and mortality. Using the WHO Global database on the Implementation of Nutrition Action (GINA) for information on the nutrition policies and actions in countries. GINA provides data on 2,158 nutrition policy changes enacted by 198 countries around the world over the last several decades.
- Education: Average years of education completed for ages 15+.

Appendix

Age and Sex Adjustment Using 2010 World Population Estimates

Age and sex adjustment, using the direct method, is the application of observed age-sex-specific rates to a standard age-sex distribution to eliminate differences in crude rates in populations of interest that result from differences in the populations' demographic distributions. This adjustment was done to compare death rates from 1950 to today, across the full variety of countries.

This report applied age-sex-adjustment weights, based on the United Nation's year 2010 estimated world population distribution. Age-sex mortality data are taken from the World Health Organization (WHO). These data are raw – provided to WHO by national statistical agencies and have not been revised. To best control for differing national data gathering capacities, death rates are calculated using national death records and national population records provided to WHO.

Calculation is as follows:

$$\text{standardized death rate}_{c,t} = 100,000 * \sum \frac{(\text{Deaths}_{c,t,a,s})}{(\text{Population}_{c,t,a,s})} * w_{a,s},$$

given $w_{a,s} = \frac{\text{Population}_{a,s}^*}{\text{Population}_{Total}^*}$ and $\sum w_{a,s} = 1,$

where country-year-age-sex-specific (*c,t,a,s*) death rate (deaths/population) data are multiplied by age-sex-specific (*a,s*) standard weights (*w*). After weighting, we sum up all age-sex pairs and multiply by 100,000 to get one age-sex-adjusted death rate for each country-year.

The weights and procedures shown below are not intended as fixed rules for age/sex adjustment, but rather as guidelines to promote and facilitate consistency and comparability in age/sex-adjustment procedures among reported data.

Table 1. UN 2010 Age-Sex weights

sex	Ages 0-4	Ages 5-14	Ages 15-24	Ages 25-34	Ages 35-54	Ages 55-74	Ages 75+
Female	0.045213	0.084230	0.085529	0.075331	0.122962	0.064741	0.017801
Male	0.048432	0.090071	0.090087	0.077832	0.12493	0.060683	0.012146

Development of Nutrition Policy Variable

The Global database on the Implementation of Nutrition Action (GINA) was developed by WHO's Department of Nutrition for Health and Development (NHD). The Department monitors the progress of national-level nutrition programs and policies across approximately 200 countries. It is informed by WHO's annual policy reviews, routine policy monitoring activities, and regional partner databases. GINA provides a repository of these policies, actions, and mechanisms related to nutrition. This includes micronutrient deficiencies, stunting in children, breastfeeding initiatives, overweight/obesity, and NCD policies. This paper will utilize nation-level policies available for 198 countries. 2158 policies have been published from 1970, onward.

When developing the nutrition policy variable, I begin by aggregating a list of total nutrition policies implemented as of 1970 for every available country. Each policy contains a detailed list of what interventions it is aimed at (called *topics*) as well as the start date and end date (if known). I categorize all the policies into four high-level nutritional themes based on their topics.

To translate these policies into panel data fit for quantitative analysis, each time a policy began its respective high-level theme was given a (+1) and each time a policy ended it was given a (-1). A (0) was given if a policy neither ended nor began. That is, annual flow data of policies represents the net gain (loss) of policies for each specific theme. Stock of policies in year t is therefore calculated as stock ($t-1$) + flow (t) – beginning with a stock of zero in year 1970 (start of database). This quantification allows us to analyze the size of a country's nutrition policy framework as well as the effects of changes to the existing policy framework on their desired outcomes.

Themes were categorized by its relevant sub-categories as follows:

Table 2. High-level Policy Themes and Topics

Policy Themes	
Overweight and diet-related NCDs	1
Maternal, infant and young child nutrition	2
Vitamins and other micronutrients	3
Acute malnutrition	4

Topics			
<i>Maternal, infant and young child Nutrition</i>	<i>Acute Malnutrition</i>	<i>Vitamins and other micronutrients</i>	<i>Overweight and diet-related NCDs</i>
Breastfeeding	Food distribution	Anaemia	Creation of healthy food environment
Stunting in children 0-5 yrs	Underweight in women	Food security and agriculture	Overweight, obesity and diet-related NCDs
Underweight in children 0-5 years	Management of moderate acute malnutrition	Vitamin A	Overweight in adolescents
Low birth weight	Growth monitoring and promotion	Food fortification regulations	Overweight in school children
International Code of Marketing of Breast-milk Substitutes	Management of severe acute malnutrition	supplementation for prevention of acute malnutrition	Overweight in children 0-5 yrs
Breastfeeding Complementary feeding		Iodine deficiency disorders	Overweight in adolescents
Anaemia in pregnant women			Food labelling
Breastfeeding promotion/counselling Baby-friendly Hospital Initiative (BFHI)			Trans fat intake Nutrient declaration (i.e. back-of-pack labelling)
Counselling on feeding and care of LBW infants malnutrition			Mandatory for all pre-packaged foods Amount of trans fatty acids

Table 3. Countries by GDP per Capita

Country and income classifications are defined using International Monetary Fund Country and Lending Group Gross National Income (GNI). This paper reviews the following countries starting from 1961-2016.

EMERGING MARKET ECONOMIES		
Albania	Georgia	Vincent and the Grenadines
Antigua and Barbuda	Grenada	Suriname
Argentina	Guatemala	Thailand
Armenia	Guyana	Trinidad and Tobago
Azerbaijan	Hungary	Tunisia
Bahamas, The	Iran	Turkey
Bahrain	Jamaica	Turkmenistan
Barbados	Jordan	Ukraine
Belarus	Kazakhstan	Uruguay
Belize	Kuwait	Venezuela
Bosnia and Herzegovina	Macedonia, FYR	Serbia
Brazil	Malaysia	Seychelles
Brunei Darussalam	Maldives	South Africa
Bulgaria	Mauritius	Sri Lanka
Cabo Verde	Mexico	St. Kitts and Nevis
Chile	Montenegro, Rep. of	St. Lucia
Colombia	Oman	Fiji
Costa Rica	Panama	Russia
Croatia	Paraguay	
Dominica	Peru	
Dominican Republic	Philippines	
Ecuador	Poland	
Egypt	Qatar	
El Salvador	Romania	
ADVANCED ECONOMIES		
Australia	Iceland	Portugal
Austria	Ireland	Puerto Rico

Belgium	Israel	San Marino
Canada	Italy	Singapore
Cyprus	Japan	United States
Czech Republic	Korea	Sweden
Denmark	Latvia	Switzerland
Estonia	Lithuania	Taiwan Province of China
Finland	Luxembourg	United Kingdom
France	Macao SAR	Netherlands
Germany	Malta	Spain
Greece	Hong Kong SAR	New Zealand
Norway	Slovak Republic	
New Zealand	Slovenia	

Distributed Lag Length Selection

Distributed lags deal with the current and lagged effects of an independent variable on the dependent variable. In order to select an optimal lag length, I will choose the lag length $p \leq P$ that maximizes R^2 .

Since this method tends to “overfit” our lags, a high significance level should be used for the F-Test ($\alpha = .01$)

For my analysis, I found that the application of a 7-year lag was optimal. Joint significance was met, as seen below.

Test for Joint Significance

```
test L0.stock_mch_ncd L1.stock_mch_ncd  
L2.stock_mch_ncd L3.stock_mch_ncd  
L4.stock_mch_ncd L5.stock_mch_ncd  
L6.stock_mch_ncd L7.stock_mch_ncd
```

- (1) stock_mch_ncd = 0
- (2) L1.stock_mch_ncd = 0
- (3) L2.stock_mch_ncd = 0
- (4) L3.stock_mch_ncd = 0
- (5) L4.stock_mch_ncd = 0
- (6) L5.stock_mch_ncd = 0
- (7) L6.stock_mch_ncd = 0
- (8) L7.stock_mch_ncd = 0

```
F( 8, 49) = 2.55  
Prob > F = 0.0209
```

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