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PRO-POOR HPAI RISK REDUCTION

Methodologies for Examining the Nutrition Impact of HPAI

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Africa/Indonesia Team Working Paper No. 11

Table of Contents

Page

PREFACE II
1. DIETARY INTAKE SURVEYS 1
2. HOUSEHOLD EXPENDITURE SURVEYS 2
3. ANTHROPOMETRY 3
4. NUTRITIONAL BIOMARKERS AND FUNCTIONAL OUTCOMES 4
5. MORBIDITIES 5
6. OTHER FACTORS, CONFOUNDING OR OTHERWISE 7
7. LITERATURE CITED 9

List of Appendices

Appendix Figure 1. Conceptual Framework For Nutrition-Related Impacts of HPAI 11
Appendix Figure 2. Life Cycle (ACC/SCN) 12

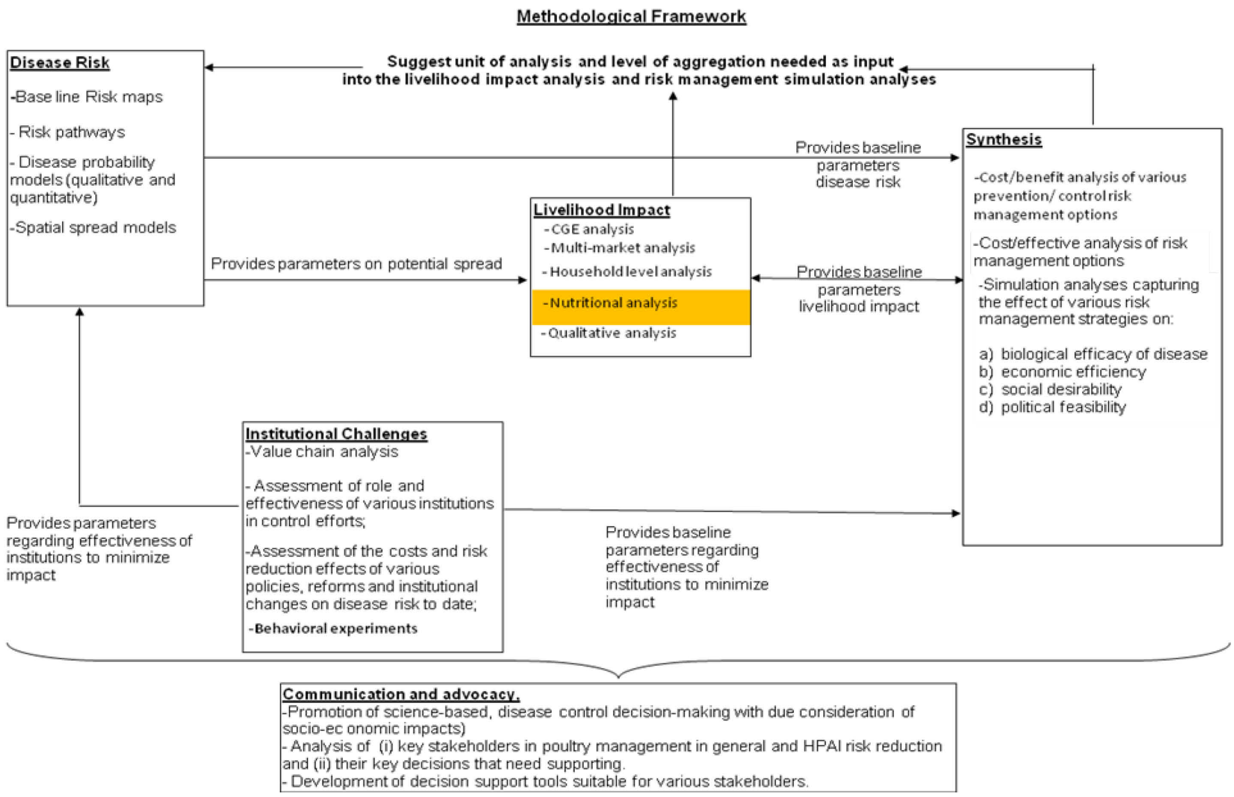
Preface

Since its re-emergence, HPAI H5N1 has attracted considerable public and media attention because the viruses involved have been shown to be capable of producing fatal disease in humans. While there is fear that the virus may mutate into a strain capable of sustained human-to-human transmission, the greatest impact to date has been on the highly diverse poultry industries in affected countries. In response to this, HPAI control measures have so far focused on implementing prevention and eradication measures in poultry populations, with more than 175 million birds culled in Southeast Asia alone.

Until now, significantly less emphasis has been placed on assessing the efficacy of risk reduction measures, including their effects on the livelihoods of smallholder farmers and their families. In order to improve local and global capacity for evidence-based decision making on the control of HPAI (and other diseases with epidemic potential), which inevitably has major social and economic impacts, the UK Department for International Development (DFID) has agreed to fund a collaborative, multidisciplinary HPAI research project for Southeast Asia and Africa.

The specific purpose of the project is to aid decision makers in developing evidence-based, pro-poor HPAI control measures at national and international levels. These control measures should not only be cost-effective and efficient in reducing disease risk, but also protect and enhance livelihoods, particularly those of smallholder producers in developing countries, who are and will remain the majority of livestock producers in these countries for some time to come.

To facilitate the development of evidence based pro-poor HPAI control measures the project is designed so that there are five work streams: disease risk, livelihood impact, institutional mechanisms, risk communication, and synthesis analysis. Project teams are allocating and collecting various types of data from study countries and employing novel methodologies from several disciplines within each of these work streams. So that efforts are not duplicated and the outputs of one type of analysis feeds into another, the methodologies in each work stream will be applied in a cohesive framework to gain complementarities between them based on uniformity of baselines and assumptions so that policy makers can have consistent policy recommendations. The figure below the methodological framework used to depict how work stream outputs fit together. This brief details the methodologies to be used for the nutritional impacts, which is highlighted in the methodological framework below.


Methodological Framework
Disease Risk
-Base line Risk maps
- Risk pathways
- Disease probability models (qualitative and quantitative)
-Spatial spread models
Suggest unit of analysis and level of aggregation needed as input into the livelihood impact analysis and risk management simulation analyses
Provides baseline parameters disease risk
Synthesis
-Cost/benefit analysis of various prevention/ control risk management options
-Cost/effective analysis of risk management options
-Simulation analyses capturing the effect of various risk management strategies on:
a) biological efficacy of disease
b) economic efficiency
c) social desirability
d) political feasibility
Livelihood Impact
- CGE analysis
- Multi-market analysis
- Household level analysis
- Nutritional analysis
- Qualitative analysis
Provides parameters on potential spread
Provides baseline parameters livelihood impact
Institutional Challenges
-Value chain analysis
- Assessment of role and effectiveness of various institutions in control efforts;
-Assessment of the costs and risk reduction effects of various policies, reforms and institutional changes on disease risk to date;
-Behavioral experiments
Provides parameters regarding effectiveness of institutions to minimize impact
Provides baseline parameters regarding effectiveness of institutions to minimize impact
Communication and advocacy.
-Promotion of science-based, disease control decision-making with due consideration of socio-ec onomic impacts)
- Analysis of (i) key stakeholders in poultry management in general and HPAI risk reduction and (ii) their key decisions that need supporting.
- Development of decision support tools suitable for various stakeholders.

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More information

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Few have studied the impact of highly pathogenic avian influenza (HPAI) disease shock on human nutrition. While issues related to food safety and HPAI have been addressed in some industrialized countries, little has been done to understand how the epidemic together with the government and general population responses has affected the nutrition of those living in developing countries. The following methodologies are proposed for investigating nutritional impact of an avian influenza shock for the Pro-Poor HPAI Risk Reduction Strategies Project. **Figure 1** in Appendix A presents the proposed framework for this analysis.

1. Dietary Intake Surveys

Rationale: Micronutrient deficiencies occur when the diet lacks an adequate supply of particular essential nutrients, or when other nutrients such as the phytates found in many staple foods interfere with the absorption of these nutrients. Poultry and poultry products are important bioavailable sources of vitamin A, iron, and zinc - micronutrients that are crucial for both health and development. Hidden hunger, or the problem of micronutrient deficiencies, affects millions globally. It is estimated that between 100-140 million children are vitamin A deficient and 4.4 million have xerophthalmia (West 2002). Approximately one-third of world's population are thought to have diets deficient in zinc. Anemia, which affects 42% pregnant women and 47% preschool children worldwide, arises from multiple causes, but some estimate that 50-60% of anemia is attributable to iron-deficiencies (Rastogi R. and Mathers 2000).

Poultry products comprise a very small fraction of total calorie intake for populations living in Sub-Saharan Africa, approximately 0.6% of a 2,077 kcal/person/day diet, and in Asia, approximately 2.9% of 2,300 kcal/person/day (FAO 2006). However, in terms of the bioavailable sources of micronutrients in particular, poultry and poultry products are critical. Poultry products contribute 20% of meat consumption in Sub-Saharan Africa and Latin America, and rises to 50% in Central America and the poorer countries of Middle East (Egypt)(FAO, 2006).

Description: In order to investigate how HPAI and responses influence the diets of vulnerable groups especially, dietary intake surveys may be used. The 24-hour recall survey repeated on different days of the week for the same subject or multiple subjects is a preferred method for obtaining measures of usual dietary intake. The subject or the caregiver of the subject is asked to recall the exact foods consumed during the previous 24 hours. Multiple pass interviewing is recommended (Gibson and Ferguson 1999) with the first pass including only a list of the consumed foods and beverage. The second pass, applying standardized probes, extracts more detail about the foods and cooking methods. For the third pass, foods are quantified using food models and measuring utensils. Another pass may seek information about any additional items such as vitamin and mineral supplements to ensure reporting is accurate (Gibson 2005). Data being used for analysis of the HPAI and nutrition impact question contains information obtained from a 7-day recall.

Advantages & Disadvantages: There are several advantages of this method. First, it minimizes participant burden and does not require literacy. Second, with a well-trained enumerator, usual dietary intakes may be accurately collected because the recall period is short. The dietary intake surveys allow for the creation of dietary diversity indicators which may serve to approximate micronutrient nutrition (Ruel, Brown, and Caulfield 2003). The probability of nutrient adequacy may be calculated using results from the 24-hour recall.

Disadvantages of the method include the expense and time involved for survey administration. Extensive training of enumerators is necessary. Another difficulty is that the within-person variability associated with particular micronutrients over several days requires that multiple 24-hour recalls be conducted to ensure reliability. Rather than repeated surveys on one individual, however, the sample size may be increased across different days of the week to minimize the standard error inflated by the within-subject variability. Seven-day recall surveys may result in reduced precision due to the longer recall period. Another potential disadvantage if secondary data is used, may be improper grouping of the foods of interest. For example, respondents may have been asked whether they consumed any meat in the past week, without disaggregating fish, poultry, or beef.

Relevance for HPAI: 24-hour and 7-day recalls permit the calculation of usual intakes for individual nutrients in addition to frequency of particular food intakes. In looking at the impact of HPAI on nutrition, attention will be focused on the micronutrients of iron, zinc, and vitamin A described above based on widely recognized deficiencies in affected populations. However, it will also be possible to consider other vitamins, minerals, and the nutrients potentially interfering with absorption such as phytates and oxylates. The extent to which poultry and poultry products contribute to the diets of affected populations may be determined using these methods. Additional information pertaining to HPAI risks may also be collected. For example, how poultry meat and eggs are prepared for consumption may be better understood. Preparation, cooking, and storage practices of poultry products may be incorporated into the surveys to investigate risks associated with handling and consumption.

The consumption data may also be combined with information collected at the household level on foods produced or purchased that are consumed to establish dietary source more precisely and potentially, the changes in dietary intakes resulting from the decreased income or production pathways of HPAI shock. Other markers of nutritional status such as anthropometry and biomarkers may also be analyzed with the consumption data to further establish causal links. DHS data provides data using 24-hour recall among young children and mothers. Finally, panel data will allow for the tracking of patterns of change in dietary intakes for the populations of interest.

2. Household Expenditure Surveys

Rationale: Poultry products may be produced and consumed by household members, or alternatively, the products may be sold or bartered to obtain resources. This income, in turn, may be used to purchase other foods that might supplement the staples consumed by the family, and usually contributing dietary variety and quality. Thus, to be able to characterize the potential risks of HPAI on nutrition, the following pathway should be considered: *poultry product sales→ income → food expenditures*.

Description: Household expenditure surveys (HES) are generally used to capture expenditures on a variety of goods including education, housing, health, and food (Smith and Subandoro 2007). For nutritional impact, we are primarily interested in the information pertaining to expenditures on particular foods and the proportion of total expenditures or the food budget allocated to these foods.

Advantages & Disadvantages: The advantage of HES is that it may be used in combination with dietary intake surveys for validation and supplementary purposes. As well, indicators may be derived from HES that characterize diet quantity and quality - though more generally and with less precision than the dietary intake surveys. Yet it may be used to corroborate the intake data, and most importantly, to understand elasticities associated with food and varying food types in relation to other expenditure priorities within the household. The disadvantages of HES are that it does not measure food wasted or given to animals and non-household members. As well, the HES is an imprecise measure of food energy availability and specific nutrient intakes. Intra-household allocation of food is not taken into consideration (Smith and Subandoro 2007).

Relevance for HPAI: The HPAI effects on nutrition may arise from reduced food availability or food access. The income and price demand elasticities associated with household food expenditures will further reveal causal links between HPAI and nutritional outcomes. HES are needed to understand the risks to nutrition incurred through household food expenditures. As well, estimations of change in other purchased goods and services for known factors associated with nutrition (education, health care, etc.) will be important for HPAI risk assessment.

3. Anthropometry

Rationale: Anthropometry is used worldwide to represent nutritional status. In the recent Lancet series on Maternal and Child Undernutrition, it was the main method used for reporting on and calculating disability adjusted life years (DALYs) associated with nutrition (Black et al. 2008).

Description: Anthropometry is the measurement of the physical dimensions of the human body to approximate size, growth, and body composition as markers of nutritional status. The usual measurements taken include: weight; height; length (for children less than 2 years); head, mid-upper arm, and calf circumferences; and skinfold measures. Z scores may be calculated using international standards based on age and sex, and indices created at varying cut-offs to represent different forms of malnutrition. Cut-offs have been established based on health outcomes to classify nutritional status. For example, weight-for-age Z score (WAZ) < -2 in children is commonly referred to as underweight and is used globally as a simple indicator of undernutrition. Weight-for-height Z score (WHZ) < -2 is referred to as wasting and generally thought to represent a shorter-term nutritional deficits in acute situations. Height-for-age Z score < -2 is termed “stunting” and suggests a longer-term, chronic nutrition insufficiency manifested in reduced linear growth. Standard procedures are commonly used to take anthropometric measures (Lohman, Roche, and Martorell 1988) and the new *WHO Growth Standards* (2006) should be used to calculate Z scores.

Arm and calf circumferences may be combined with skinfold measures of adiposity to estimate lean and fat tissue mass or body composition. Arm and calf muscle and fat areas are calculated with the following equations: $\text{area} = \pi/4*(\text{circumference}/\pi)^2$; $\text{muscle area} = [\text{circumference} - (\pi*\text{skinfold thickness})]^2/4\pi$; fat area = area - muscle area (Frisancho 1981). In adults, body mass index (m/kg^2) is often used:

Advantages & Disadvantages: The advantage of anthropometry is that is a simple, non-invasive technology which can be easily used at the field level. Little training is required, and measures tend to be precise and accurate. Equipment for measuring anthropometry is portable and inexpensive. The primary disadvantage of anthropometry is that it may not reflect qualitative changes in the diet, or micronutrient deficiencies, in the short-term. Other specificity and sensitivity issues may arise from disease, genetics, and diurnal variations (Gibson 2005).

Relevance for HPAI: Anthropometry allows for a baseline understanding of the population background nutritional status and susceptibility of populations to the consequences of HPAI. Changes in anthropometric measures in infants and young children in particular may indicate impacts on food insecurity resulting from HPAI and suggest increased morbidity and losses of human capital in the future. As well, anthropometric measures may suggest micronutrient deficiencies. Vitamin A, iron, and zinc are all required for growth and development (2005). Prevalence of stunting has been used as a proxy marker for zinc deficiency and may be applied for HPAI (Hotz and Brown 2004). Because there is a hypothesized effect of HPAI on micronutrient deficiencies, anthropometric indicators may also serve to represent the downstream effects of an HPAI shock mediated through micronutrient deficiencies.

Regression modeling may be applied using anthropometric indicators as dependent variables and incorporating other mediating or mitigating factors such as morbidity, socio-economic status, sanitation and/or hygiene factors, asset-related indices, infant feeding practices, etc.

4. Nutritional Biomarkers and Functional Outcomes

Rationale: Micronutrient deficiencies is an important potential impact of HPAI. These deficiencies may occur as diet quality is compromised due to reductions in the availability of poultry products or income from the sale of poultry products. The micronutrients of concern in this project (as described above) are vitamin A, zinc, and iron. Vitamin A deficiencies elevate the risk of diarrhea-related mortality by 47%, and measles-related mortality by 35%. It has been estimated that vitamin A deficiencies alone account for 6% of all childhood deaths (Black 2008). Vitamin A is also critical for eye health. Animal source foods contain preformed vitamin A (retinyl esters) which are significantly more bioavailable than the provitamin A found in plant-based foods (β-carotene, α-carotene, β-cryptoxanthin). Vitamin A is necessary for vision, gene expression, growth, reproduction, embryonic development and immune function; deficiencies result in xerophthalmia and night blindness, poor growth, morbidities (measles, diarrhea, malaria), and mortality.

Iron and zinc are more bio-available when introduced into the body with proteins found in meats or animal source foods. Zinc is present in over 300 enzymes, playing structural and regulatory roles, involved in gene transcription and regulation, and is important for immune functioning, growth, and development. Iron in the body is needed for oxygen transport, enzyme activity in cellular respiration, division, neurotransmission, immunity, and growth. The rate of absorption for heme iron, found in meat, fish, and poultry, is 15-35%, while the rate of absorption for non-heme iron found in vegetables, fruits, and grains is only 2-20% (Ruel et. al 2001).

Description: There are few biomarkers of micronutrient status that are widely used in large population surveys. This is because of the invasive nature of collecting blood samples, as well as issues of validity and cost. Anemia is often used as a proxy indicator of iron deficiency, though only about half of anemia in developing countries is thought to result from iron deficiencies. Anemia may be measured by determining hemoglobin concentrations and applying established cut-offs. An inexpensive, field-friendly method widely used is Hemocue which requires only a finger prick. Serum or plasma ferritin (the iron storage protein in the body) concentrations may be combined with hemoglobin to more accurately determine iron deficiency. Serum retinol may be used for vitamin A if populations are severely depleted, but does require venous blood, careful storage of samples, and generally high-performance liquid chromatography analyses. A functional outcome that may be applied here is night blindness requiring a rapid dark adaptation test.

Advantages & Disadvantages: Nutritional biomarkers and other clinical outcomes may more closely approximate the functional outcomes or health manifestations of nutritional problems. However, as stated above, the techniques used to obtain these measures may be considered invasive, require laboratories and equipment, and generally be too costly to obtain. There are other issues related to the validity of some of the markers (Gibson 2005). Serum retinol, for example, may more accurately indicate vitamin A status when liver stores are low. Anemia, a commonly used marker of iron deficiency, in fact results from multiple causes; iron deficiency is thought to comprise about half of anemia-related causes worldwide as stated above. Finally, some markers such as serum ferritin and retinol may also be affected by infection status.

Relevance for HPAI: Nationally representative studies have been conducted in most countries to obtain nutrition biomarkers in an effort to characterize micronutrient deficiencies especially. For example, the DHS is now collecting a range of biomarkers that include some related to nutrition. These results may be used to present some indication of the nutritional status of the populations both as the baseline status on which the HPAI shock is introduced, and potentially in association with its nutritional impact over time. An alternative to collecting biomarkers that may also be applied for this study to approximate nutritional risk associated with HPAI shock might be estimates of supplementation coverage for such nutrients as iodine, vitamin A, and iron; this information is under surveillance in certain populations (UNICEF 2006).

5. Morbidities

Rationale The interaction between malnutrition and disease has been a long recognized phenomenon (Scrimshaw 1968). One condition is known to exacerbate the other. Undernutrition has been associated with increased risk of deaths due to infectious disease, with some studies disaggregating proportional risk due to particular infectious diseases(Caulfield et al. 2004). In the recent Lancet series, it was determined that over one-third of all deaths to children less than 5 years of age and 140.5 million of DALYs result from the nutrition risk factors of stunting, severe wasting, intrauterine growth restriction (IUGR), sub-optimal breastfeeding, vitamin A and zinc deficiencies (Black et al. 2008). Micronutrient deficiencies are most often associated with increased disease severity and duration.

In this project, there is a need to consider the presence of morbidities in the study population in order to: 1) determine the baseline level of risk for malnutrition induced by HPAI shock; 2) predict resulting disease, symptom severity, and mortality resulting from increased malnutrition or co-infections. Those morbidities of particular importance in this context include: human immunodeficiency virus infection; diarrheal diseases; respiratory infections; helminthes infections; malaria and other parasitic infections. Special consideration should be given to HIV because there has been limited studies to date evaluating the potential effects of HPAI superimposed on populations with high prevalences of HIV and low coverage of antiretroviral therapy – both in terms of the health and livelihoods of these populations (Gillespie and Kadiyala 2005).

Description: Morbidity recall data is usually collected using a 2-week recall period. Field workers question subjects or caregivers about episodes of cough, fever, or diarrhea in the previous 14 days. Morbidity parameters may later be created based on the responses and information in the literature associating symptoms with particular conditions. For example, acute diarrhea in infants can be defined as 3 or more liquid or loose stools in a 24-hour period (Baqui et al. 1991). Further, the indicator may be further modified to reflect the longitudinal prevalence of diarrhea*,* calculated by summing the total number of days with acute diarrhea over the total number of days of observation. This index has advantages for use in modeling because of its association with growth and nutrition (Morris et al. 1996). Cough combined with rapid breathing or elevated heart rates may be used for describing respiratory conditions, while fever or parasitic density are often applied for use in characterizing malaria prevalence. HIV testing involves collecting a blood spot on filter paper, that is later processed and tested using an ELISA, that may followed up with a second ELISA and Western blot depending on the results (Measure DHS 2008).

Advantages & Disadvantages: Characterizing the morbidities in a population provides additional insights into the relationship between HPAI and nutrition. Morbidities may be used to represent particular nutritional states or may be considered as confounding factors in the association. The disadvantage of using morbidity data is that it may require more intensive surveying to keep the recall period short. More training and higher skill levels may be required for enumerators depending on the conditions being collected. As well, there may be costs involved in with laboratory testing.

Relevance for HPAI: Morbidities are very likely playing an important role in the pathways through which an HPAI shock affects nutrition and ultimately human capital (**Figure 1**). The baseline health status of a population will be an important variable for modeling susceptibility of populations to nutritional deficiencies due to HPAI, and the consequent DALYs further downstream. Not only from a biological standpoint, but as well through income and asset shocks that lead to reductions in access to health care services for example, morbidities may be increased. By collecting and analyzing morbidity data in association with these variables, the multiplicative effect of combined nutritional deficits will better elucidate HPAI effects on lost human capital.

6. Other factors, confounding or otherwise

Rationale: There are a number of potential confounding and mitigating factors that should be considered when modeling the effects of HPAI and control measures for nutrition outcomes. These factors are displayed in the yellow shaded boxes of the conceptual framework (**Figure 1**).

1) *Baseline nutritional status.* Responses to interventions or environmental conditions potentially altering nutrition can be dependent on the baseline nutritional status of an individual. These effects are usually of greater magnitude in depleted or undernourished populations, though this depends on the nutrient in question. Ideally, data would be available for: weight-for-age Z score; height-for-age Z score; weight-for-height Z score; prevalence of anemia; prevalence of low birth weight; and other available indicators.

2) *Income and price elasticities*. It is anticipated that HPAI will be found to impact nutrition via the income pathway. The extent of this impact will in part be determined by both income and price elasticities of demand. As income is reduced due to an HPAI shock, households may adjust food choices which may be further influenced by market prices. Previous studies have shown that calorie-income elasticities tend to be low, while elasticities for higher quality foods are high (Ahmed 1993;Bouis and Haddad 1990). Thus, consideration of household level decision-making around food expenditures over time could be an important mitigating factor in such outcomes as micronutrient deficiencies. The macro-effects of the current rising food prices could also influence the HPAI impact on nutrition, and will be considered in the analyses.

3) *Vulnerable group demographics.* Certain strata of the population may be considered more vulnerable to malnutrition; thus, these characteristics are important to incorporate into modeling HPAI effects on nutrition. Position in the life cycle is a common approach to identifying vulnerable groups to malnutrition (**Figure 2**). Those considered most vulnerable include: fetus (conception through birth); infants (0-1 yr); young children (1-5 yr); pregnant and lactating women; and the elderly. Other socio-demographic characteristics will be included based on previous evidence for confounding and mitigating effects on nutrition: sex; parity; level of education of mother; and rural/urban residence.

4) *Infant feeding practices*. Infant feeding practices have long been recognized to be important determinants of nutrition. As well, infant feeding practices are associated with morbidity and mortality outcomes (Black et al. 2008). Thus in differing populations, there will be a need to adjust for the following practices in particular: early initiation of breastfeeding (Edmond et al. 2006); exclusive breastfeeding (Piwoz et al. 1996); continued breastfeeding; and a range of complementary feeding practices (Brown, Dewey, and Allen 1998;Dewey and Brown 2003;Ruel, Brown, and Caulfield 2003).

5) *Hygiene and sanitation practices.* Hygiene and sanitation practices can be important determinants of child growth and nutrition outcomes (Checkley et al. 2003), as well as morbidity factors influencing nutrition outcomes (Checkley et al. 2004;Fewtrell et al. 2005). Possible indicators that may be available for adjusting for the potential for confounding

include: hand washing; type of toilet; disposal method for of wastes; etc. Some care should be granted the interpretation of results for particular behaviors such as hand washing with known reporting biases (Ruel and Arimond 2003).

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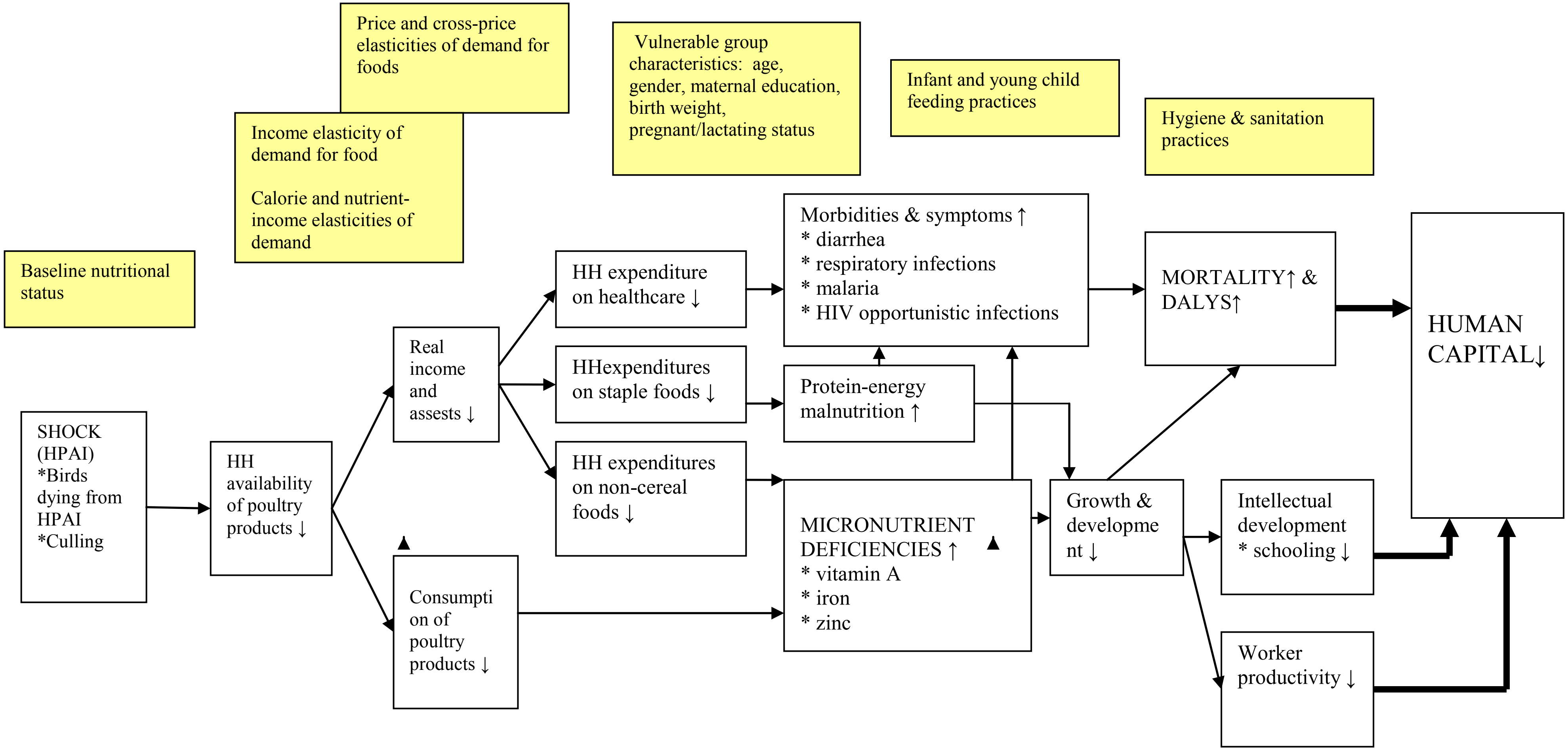
APPENDIX Figure 1. Conceptual framework for nutrition-related impacts of HPAI



Appendix Figure 2. Life cycle (ACC/SCN)