**The Effect of Housing Attributes on Occupant Health in a Less Developed Country: Evidence from Uganda**

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# The Effect of Housing Attributes on Occupant Health in a Less Developed Country: Evidence from Uganda*

**Abstract**

This paper uses the third round of the Uganda National Household Survey (UNHS III) to study the relationship between housing quality and resident health. Poisson and negative binomial regressions estimate the number of days ill in a 30-day time interval as a function of, among other things, measurable housing characteristics. We show that some, but not all, of these characteristics adversely affect health. Most notably, we find that indoor burning necessary for cooking and lighting affects different measures of illness in expected ways. Consistent with other work, we find that household crowding also adversely affects health. Estimated coefficients for control variables and a separate specification test suggest that our findings are reasonably robust.

## I. Introduction

Although a substantial literature exists that studies housing and health in developed countries, the relationship is neither clear nor well-understood (Cassel, 1977; Matte and Jacobs, 2000). Moreover, comparatively little work has focused on the housing-health relationship in less developed countries. This seems surprising because the housing circumstances in poor countries are in general much less satisfactory than those in wealthier ones, which intuitively suggests that the health consequences are more substantial and thus easier to document.

There is no obvious reason why so little attention has been paid to the housing-health relationship in less developed countries. One possible reason follows from the complex nature of the relationship so well documented for wealthier nations. This complex relationship makes it difficult to empirically untangle the many and varied

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influences on health from those due solely to housing. For example, in wealthier Western countries, socioeconomic disadvantage, which leads to adverse health, also limits the ability to secure better quality housing. Moreover, poor health may cause the socioeconomic disadvantage that leads to poor housing outcomes. Empirically disentangling such relationships requires very detailed data on housing attributes that affect the housing-health relationship. With some exceptions (discussed below), it seems that such data are neither readily available nor accessible.

This paper studies the relationship between housing quality and health indicators in Uganda, a relatively less developed but rapidly growing East African nation. It uses the Uganda National Household Survey (UNHS), a very rich but not well known stratified random sample of Ugandan households from both rural and urban areas. It consists of individual, household, and community level information that includes, among other things, many measures of individual and household health. It also includes an unusually rich set of measures of the physical quality of a dwelling as well as the neighborhood in which the dwelling is located. This richness allows us to analyze the housing-health relationship in a less developed country more carefully than has been previously possible.

## II. Background

### A. The housing-health relationship in developed countries

Researchers in the social, environmental, and health sciences have been interested in the relationship between health and housing quality for some time. The relationship between the physical quality of a dwelling and the health characteristics of its inhabitants is well documented by sociologists. Burridge and Ormandy (1993) and Fuller-Thomson, Hulchanski, and Hwang (2000) provide reviews of this work, and emphasize that there are no firm conclusions to be drawn from the findings. Hartig and Lawrence (2003) expand this work by more broadly defining housing as "residence," which includes the physical characteristics of the structure as well as the locational aspects of its surroundings and review other work within this broader definition. In this context, Muhajarine et al. (2008) assess the intervening effect of neighborhood quality on the relationship between housing and health, while van Kamp et al. (2004) discuss conceptual and methodological issues pertaining to health differences between poor and prosperous neighborhoods.

The public health literature also contains much work on the housing-health relationship. Many reviews exist. Saegert et al. (2003), for example, summarize the efficacy of public health interventions related to housing in the United States between 1990 and 2001, while Thomson, Petticrew, and Morrison (2001) survey interventions in the United Kingdom. Similarly, Matte and Jacobs (2000) provide an overview of the myriad ways in which the home environment can affect health, yet they emphasize that demonstrating a causal relationship in Western developed countries is difficult.

This difficulty is documented in some earlier work that analyzes the relationship. Cassel (1977) questions the role played by both crowding and physical housing quality in determining health. He notes that a review of literature since early in the 20th century reveals studies that show both positive and negative relationships between housing quality and various indicators of poor health as well as others that show no relationship. Cassel documents a movement away from the conviction that poor housing causes poor health to more uncertainty regarding this relationship. While he acknowledges that crowding may be linked to a greater likelihood of communicable disease under some circumstances, this link is much more tenuous than policymakers assume. Following this, Hinkle (1977) and Kasl (1977) provide evidence to support Cassel's position.

Matte and Jacobs (2000) also note that progress in understanding the housing-health relationship may be hampered by the rather myopic nature of the bulk of the research. Focusing solely on lead poisoning, for example, may miss an important interaction between interior wall quality and other health problems. Along these lines, Lawrence (2004) makes a compelling argument for the importance of interdisciplinary approaches to addressing the problem.

Notwithstanding these difficulties, researchers such as Smith (1990) have successfully shown a link between housing quality and a variety of health problems. Moreover, Cassel (1977) does document a link between poor housing, infant mortality, and overall mortality rates. Others have reported a relationship between housing quality and self-reported health indicators. Dunn (2002), for example, demonstrates such a relationship using data from Vancouver, B.C., and Kasl (1990) summarizes other work that demonstrates how self-reported health is related to housing quality.

**B. The housing-health relationship in less developed countries**

Although comparatively little has been done, the housing-health relationship in less developed countries has been addressed. Britten (1990) highlights the similarities and differences in housing needs between wealthy and poor countries as they pertain to the health of the residents. He notes that surveys suggest that both wealthy and poor country households value artificial lighting equally even though it is not available to many in poor countries. He also notes, however, that the importance of housing to overall household needs is generally different in less developed countries. More specifically, he notes that the evolution of the design, construction, and maintenance of housing in less developed countries, while not necessarily consistent with Western notions of health, may have far-reaching effects on the comfort and total health of its occupants.

Cairncross, Hardoy, and Satterthwaite (1990) review some important links between housing and poor health in less developed countries. This work contains studies that address, in mainly engineering terms, problems associated with water supply contamination, household waste removal, and other similar problems. Goldstein (1990) takes a global perspective on health and well-being as it relates to housing in an urban environment. He explains housing and health trends and considers ways to improve poor housing conditions like those addressed in the Cairncross book through leadership from public health agencies.

Like Goldstein (1990), others study the housing-health relationship in the context of growing urbanization. Comaru Fde and Westphal (2004), for example, argue that integrated health and environmental policy is needed to improve the health of rapidly growing urban areas in Brazil. Like studies of wealthy countries, Mathee et al. (2004) explore the effect of lead poisoning on children in South Africa. Focusing on rates of sickness over time, Friel et al. (2004) show that changes in housing conditions, together with factors like health literacy, are correlated with lower disease rates in Thailand. Finally, Lawrence (2004) summarizes much of the more recent work on housing and health, including studies that focus on Latin America, Africa, and Asia. He emphasizes that a gap still exists between accumulated empirical evidence on the physical relationship between housing and health and the yet to be researched impact of cultural and semiotic factors.

Virtually all of the work done on less developed countries summarized here thus far is descriptive. Data are used solely to develop and bolster arguments, and no inferential methods are employed (e.g., Comaru Fde and Westphal (2004)). This is consistent with our conjecture that a general paucity of reliable data on housing quality may explain the dearth of work focused on the housing-health relationship in less developed countries.

There are, however, some notable exceptions. Fuller et al. (1993) use interviews conducted on a stratified random sample of 2,017 households in Bangkok, Thailand in 1988.[1] Each household represented a married couple with at least one child. They study the effect of both housing quality and crowding on psychological distress and physical well-being while controlling for a number of intervening effects (e.g., socioeconomic status and the gender of the interview respondent). Their results are generally consistent with Cassel's (1977) skepticism regarding the housing-health relationship. More specifically, objective aspects of housing quality (e.g., adequate toilet facilities) and objective measures of crowding (e.g., number of people per room) have little effect on health.[2] The authors suggest that these results may stem from their sample design, which used only relatively young adults. On the other hand, they do find that the subjective measures of housing quality and crowding have a detrimental effect on health. They also

[1] Thailand is currently classified in the World Bank's World Development Indicators Database as a lower-middle income country. Its per capita GDP in 1988 was $2,872 in PPP terms, which was the 83rd highest of the 154 countries included in this ranking.
[2] The authors also use subjective measures of housing quality and crowding obtained from the interview process. Respondents were asked their level of satisfaction with 11 aspects of the dwelling. The responses were used to construct the subjective measures of quality. Responses to a series of questions pertaining to their perceived privacy were used to construct the subjective measures of crowding.

suggest that psychological distress has a strong influence on physical health, with this effect more prevalent among women.

Finally, Ssewanyana and Younger (2008) use two measures of housing characteristics to help explain child mortality in Uganda. While these measures, water quality and quality of toilet facilities, do not explain child mortality, socioeconomic characteristics as well as childhood vaccination programs do in the expected ways.

Obviously, economists have not ignored the role health issues play in the development of poor countries. Strauss and Thomas (1998) provide an excellent survey of work that focuses on health, nutrition, and development. This work, however, does not mention how housing quality may affect health outcomes. In fact, the effect of housing on health has been addressed by the profession much more narrowly by studying the impact of indoor air pollution (IAP) on health, well-being, and development. This work is similar to that of Ezzati and Kammen (2001), who use data on exposure to particulate matter to estimate the incidence of acute respiratory illness in rural Kenya. In general, they find that illness increases with exposure at a decreasing rate.

Following this, Dasgupta et al. (2004a) show that cooking indoors with biomass fuel significantly affects IAP, but that household factors such as ventilation matter more than fuel choice. In a subsequent paper, Dasgupta et al. (2004b) analyze IAP exposure within households attributable to family roles and across households attributable to differences in income and education. Within households they find high exposure among all children while the exposure of adult men is much less than that of adult women. Across households, they find results similar to those in Dasgupta et al. (2004a).

Pitt et al. (2005) takes this work further by developing a theoretical model of exposure to IAP. Using rural data from Bangladesh, they find that proximity to cooking stoves adversely affects women and the children they supervise. Their results also suggest that households, in an attempt to efficiently allocate productive household time, have less healthy women do more cooking than those taking care of younger children. This of course exposes them to relatively more IAP.

More recent work by Duflo et al. (2008a) surveys the IAP literature and highlights the extent of the problem. Following this, Duflo et al. (2008b) reports the results of a survey of traditional stove ownership and health among almost 2,400 households in rural Orissa, India. They find that one-third of the adults and half of the children experienced respiratory illness in the 30 days preceding the survey, and that this strongly correlates with the indoor use of traditional cooking stoves.

## III. Data and Empirical Model

Household surveys in Uganda began with the first Integrated Household Survey (IHS) in 1992/93. This IHS was followed by two monitoring surveys in 1993/94 and 1994/95 and renamed the Uganda National Housing Survey (UNHS) in 1996. Three rounds of the UNHS were conducted. The first was in 1999/2000 (UNHS I), the second in 2002/03 (UNHS II), and the third in 2005/06 (UNHS III). We use the Socioeconomic component of the UNHS III here. As noted, it contains a rich set of structural dwelling characteristics as well as many indicators of occupant health. It also contains a wealth of information on food consumption and other factors relevant to our study.

The UNHS III contains data amenable to analysis at both the individual and the household level. We choose to analyze the housing-health relationship at the household level to be consistent with the theoretical model developed by Pitt et al. (2005), which maximizes a household utility function. Thus, our data consist of information on the characteristics of 7,096 urban and rural dwellings and their inhabitants. Similar to the Indian data used by Duflo et al. (2008b), the UNHS reports the number of days in the past 30 during which an occupant reports being ill from one or more of 26 different maladies. We use this information as our dependent variable. More specifically, we use the number of sick days reported by the person who was ill for the most number of days if more than one occupant reports being ill. We choose this "sickest person" to also be consistent with the Pitt et al. model. The model suggests dwelling occupants optimize household work time by having occupants with lesser health endowments (i.e., those who are, on average, less healthy) do more cooking, and thus be subjected to more IAP. Our task is to see if housing attributes adversely affect the health of any occupant. Evidence that more exposure to IAP from cooking makes one sicker helps to accomplish our task. In general, if sicker people spend more time indoors, they should be most affected by poor housing conditions. It seems reasonable to focus on these individuals.

Table 1 shows the distribution of the number of days ill out of the past 30 for our sample. The number of days ill is then explained using information on housing quality with the following general specification,

$$\textit{days ill} = f(\textit{dwelling attributes, demographics, diet, location, expenditures, surveymonth, region}), \qquad (1)$$

where *demographics* include the average age of the household's occupants and whether or not the household has a male head.[3] *Diet* controls for protein intake and for the

[3] Uganda is a very patriarchal society. This could lead to household decisions generally being made unilaterally by the male household head. Less discussion could imply poorer decisions in overall, including those that apply to issues of health.

consumption of a ubiquitous Ugandan staple, a starchy green banana called matooke, which has very little nutritional value. *Location* indicates a rural or urban location. *Expenditures* proxies income, which is not commonly reported with any consistency in the UNHS. Deaton (2000) justifies and provides evidence for using this proxy, while Morris et al. (2000) show its reliability using data from three sub-Saharan African countries. The construction of our variable follows their description.

S*urveymonth* notes the month in which the survey was taken. This controls for illness that may occur during rainy seasons or during the months that are typically hotter or colder. Finally, *region* controls for the four regions (central, east north, and west) of the country into which the data are divided. Table 2 identifies, defines, and provides summary statistics of the specific variables used in the estimation.

Because the dependent variable measures the number of days of illness out of the past 30, we posit that it is Poisson-distributed, and we explain it with a Poisson, or "count outcome" regression model.[4] A Poisson-distributed variable follows the probability distribution

$$P(daysill = daysill_i) = \frac{e^{-\mu(x)}[\mu(x)]^{daysill_i}}{daysill_i!} \qquad daysill_i = 0,1,2, \dots , \tag{2}$$

where $P(daysill = day\ ill_i)$ is the probability that the number of days ill for the sickest occupant equals $daysill_i$, and $\mu(x)$ is the expected number of days ill for the average household expressed as a function of the arguments on the right side of equation (1). $\mu(x)$ is computed as

$$\mu(x) = e^{\alpha + \Sigma_j \beta_j X_j} > 0 , \tag{3}$$

[4] A Poisson distribution measures the probability of a certain number of events occurring over an interval.

with the $X_j$ evaluated at their sample means.[5] $\mu(x) = e^{\alpha + \Sigma_j \beta_j X_j}$ assures that the mean number of days ill is positive.

The empirical counterpart to equation (1) using *all sickdays* as the dependent variable is,

$$
\begin{aligned}
\textit{all sickdays}_i = \alpha &+ \beta_1 \textit{ crowding} + \beta_2 \textit{ indwelling} + \beta_3 \textit{ hut} + \beta_4 \textit{ badroof} + \beta_5 \textit{ badwalls} \\
&+ \beta_6 \textit{ badwater} + \beta_7 \textit{ badtoilet} + \beta_8 \textit{ badlighting} + \beta_9 \textit{ badcooking} \qquad (4) \\
&+ \beta_{10} \textit{ malehead} + \beta_{11} \textit{ aveage} + \beta_{12} \textit{ matooke} + \beta_{13} \textit{ protein} + \beta_{14} \textit{ rural} \\
&+ \beta_{15} \textit{ expenditures} + \sum_{j=16}^{26} \beta_j \textit{surveymonth} + \sum_{j=27}^{29} \beta_j \textit{region} + \varepsilon
\end{aligned}
$$

with *all sickdays* being estimated with a Poisson regression. The results are reported in Table 3.

The Wald $\chi^2$ shows that the Poisson model significantly explains *all sickdays*, but the goodness-of-fit $\chi^2$ highlights a problem. This goodness-of-fit $\chi^2$ tests Ho: *all sickdays* is Poisson-distributed. The computed $\chi^2$-value and corresponding p-value shown in Table 3 show with virtual certainly that *all sickdays* is not Poisson-distributed. A quick comparison of the mean and variance of *all sickdays* shown in Table 2 shows why. A property of a Poisson-distributed variable is that its mean and variance are equal. Table 2 indicates that the variance of *all sickdays* ($89.93 = 9.483^2$) is more than eight times the size of its mean (10.96), which implies there is more dispersion in the predicted number of ill days than allowed by the Poisson distribution in equation (2). In short, the Poisson specification understates the actual amount of dispersion, which leads to an understatement of the standard errors for the estimated coefficients.

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[5] It follows that $\mu_i(x)$ can be computed for the $i^{th}$ dwelling by using the values $X_{ij}$ in the computation of $\mu(x)$ in equation (3).

A formal test for overdispersion is done by estimating the model assuming that *all sickdays* follows a negative binomial distribution and then comparing this regression to the Poisson using a likelihood ratio test.[6] The negative binomial regression estimates $\ln \gamma$, where $\gamma > 0$ is defined as the dispersion parameter. Larger values of $\gamma$ show more dispersion, and the negative binomial approaches the Poisson as $\gamma$ approaches 0.

The negative binomial estimation of equation (4) yields an estimated value of $\ln \gamma = -0.0001$, so $\gamma = 0.9999$. A likelihood ratio test of Ho: $\gamma = 0$ (i.e., no overdispersion) is then used to compare the Poisson and negative binomial regressions. This likelihood ratio comparison is computed as $\chi^2 = 2(\ln L_{NB} - \ln L_P)$, where $\ln L_{NB}$ and $\ln L_P$ are, respectively, the logs of the likelihood functions for the negative binomial and Poisson regressions. From Table 3, this dispersion $\chi^2 = 2(-24{,}202.7 + 41{,}935.8\ ) = 35{,}466.2$. Because the corresponding p-value indicates overdispersion with virtual certainly, the negative binomial is the appropriate specification.

## IV. Results

For purposes of comparison, both the Poisson and negative binomial regressions are reported in Table 3, but the discussion focuses on the negative binomial estimates. Note that Table 3 also reports incident rate ratios (IRRs), which facilitate the

[6] The negative binomial is a generalization of the Poisson. Unlike the Poisson though, it accounts for heterogeneity in the sample not captured by the explanatory variables. This heterogeneity leads to the higher variance. The negative binomial computes $\mu^*(x) = e^{\alpha+\Sigma\beta jXj+\varepsilon}$, which differs from $\mu$ in equation (3) by the error term $\varepsilon$. Assuming that $E(\varepsilon)=0$, then $E(\mu^*) = \mu$. That is, the negative binomial and Poisson distributions have the same mean.

interpretation of the estimated coefficients.[7] The IRRs show the relative effect of a unit change in the $j^{th}$ regressor on μ holding all else constant and are computed as

$$\frac{e^{\alpha+\beta_1 X_1+...+\beta_j(X_j+1)+...+\beta_k X_k+\varepsilon}}{e^{\alpha+\beta_1 X_1+...+\beta_j X_j+...+\beta_k X_k+\varepsilon}} = e^{\beta_j}, \qquad (5)$$

which are simply the antilogs of the estimated coefficients.[8]

The signs of the estimated coefficients that are statistically significant and the magnitudes of the IRRs as well as their significance levels are essentially the same in both models, lending a degree of robustness to the estimates. The positive coefficient for *crowding* suggests that more people per room leads to more days ill per month. More specifically, the IRR shows that the number of days ill is 1.072 times greater when there is an extra person per room. Stated differently, the extra person per room raises the number of days ill by 7.2%. This result is consistent with Fuller et al. (1993) who, as noted, show that subjective measures of crowding affect health. We show that an objective measure of crowding does also.

The findings suggest that living in an independent house increases the number of ill days by 13.4%, while living in a *hut* increases the number of ill days by 12.8%, which implies something inherently unhealthy about these types of dwellings independent of crowding and other structural characteristics. Also, days ill per month in dwellings with *bad walls* is 1.05 times greater than in dwellings with better wall construction.

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[7] In count outcome models such as these, μ is sometimes referred to as the "incident rate," or the rate at which incidents occur in the interval. The IRRs simply express the incidence rate as a relative, or percentage, change.

[8] Note that the IRRs for indicator variables are evaluated for a standard deviation, rather than a unit, change in the $j^{th}$ regressor. That is, the second term shown in the numerator exponent in equation (5) is $\beta_j(X_j+\sigma)$, where σ is the standard deviation of $X_j$. Note also that $\varepsilon = 0$ for the Poisson computations.

Interestingly, while inferior walls affect health, we find no evidence that a *bad roof* does.[9] We also find no evidence that *bad water* or *bad toilets* affect health, which is consistent with the findings of Ssewanyana and Younger (2008).[10]

*Matooke* is one of our controls for diet because it is consumed ubiquitously and has little nutritional value (See Muranga et al. (2007) for the biochemical details). Kikafunda, Walker, and Tumwine (2003), for example, discuss matooke's nutritional value in relation to the nutritional requirements of very young children. Indeed, we find some evidence that a percentage point increase in matooke consumption raises the number of days ill by 15.1%. We also find that a rural location raises the number of days ill per month by 6.3%, that a year increase in the average age of the household members increases the number of days ill by only 0.20%, and that a male household head lowers them by 2.5%. Finally, an increase in monthly household spending of 100,000 Ugandan shillings (Ush) raises the number of days ill by 3.9%.[11] This result appears anomalous, suggesting that spending is capturing other omitted factors.

Perhaps most enlightening, we find that both *bad lighting* and *bad cooking* increase the number of days ill. While poor methods of lighting a dwelling increase the number of ill days by 6.6%, bad cooking methods raise it by 10.4%. Our definitions of both these variables emphasize indoor burning as the source of lighting and cooking,

[9] Our definitions of inferior structural characteristics are based upon reasonable assertions of what should affect health. They are also based upon the personal experiences of the authors, who have spent extended periods of time in Uganda. Nevertheless, some Western developed country bias, however unintentional, may have entered our thinking. For example, our definition of a bad roof includes those made of thatch and straw. While there is some evidence this may be incorrect (Dasgupta et al. (2004a, 2004b) suggest that indoor smoke concentrations may be lower in dwellings with more porous roofs), we choose not to arbitrarily change our definition before we investigate further. Similarly, we show that an independent house adversely affects health. This is likely capturing some crucial omitted influence that, while not apparent to Western researchers, may be quite obvious and reasonable in a Ugandan context. Further investigation is needed here too.

[10] The coefficient on *badtoilet* is significant at the 10% level in a 1-tailed-hypothesis test.

[11] The UNHS III was conducted between May 2005 and April 2006. The 365-day average exchange rate at that time was $1=Ush 1,786.

Consistent with the findings of the above mentioned studies, IAP appears to have deleterious health effects for these Ugandan households as well.

Based upon these last findings, we explore more carefully the specific types of illnesses reported. We first examine if indoor burning leads to a higher incidence of respiratory illness, defined as a cough, coughing blood, or difficulty breathing. As a check, we then examine if indoor burning causes more gastrointestinal illness. Table 4 reports the results of negative binomial regressions that estimate the effect of the same set of explanatory variables on the maximum number of days ill in the past 30 from respiratory ailments and from diarrhea. The negative binomial regression in Table 3 is repeated in the first column of Table 4 to facilitate comparison.

The dependent variable used in the second regression in Table 4 is the total number of days in the past 30 reported ill by the sickest occupant who reports respiratory illness (*r-sickdays*). The estimated IRRs for *crowding, indwelling, and hut* remain statistically significant and of the same magnitude as those reported in the *all sickdays* regression. Moreover, the statistically insignificant regressors in the *all sickdays* regression remain so, which provides more evidence of the robustness of the model. *Rural* also loses significance here. This may be expected if the greater prevalence in rural areas of lighting and cooking via indoor burning is balanced by the generally very poor air quality in urban areas.[12] However, *matooke* is now statistically insignificant as well, which is expected in a regression that explains respiratory illness. Finally, and most interestingly, the estimated IRRs for *badlighting* and *badcooking* remain significant and have larger estimated IRR values than those reported in the *all sickdays* regression. More

[12] 92% of the dwellings in our sample that use electricity for lighting and cooking are located in urban areas. Poor urban air quality is due mostly to exhaust from the plethora of badly maintained vehicles.

specifically, *badlighting* now increases respiratory-related ill days by 7.3%, while *badcooking* raises *r-sickdays* by 19.5%.

The third regression shown in Table 4 focuses on gastrointestinal illness. The dependent variable is now the total number of days in the past 30 reported ill by the sickest occupant who reports gastrointestinal illness (*g-sickdays*). A quick comparison to the *all sickdays* regression once again demonstrates the model's robustness. *Rural* is once again significant, however, which indirectly supports the urban vehicle exhaust explanation suggested for the *r-sickdays* regression. *Aveage* is now significant with an IRR that suggests a 3.1% decline in the number of *d-sickness* days for an extra year of age. This may suggest that diarrhea is most prevalent in younger children. Finally, while *badlighting* loses significance, *badcooking* now causes a 29.7% increase in *g-sickdays*.[13] This last estimate implies that IAP is not the only detrimental health consequence of some cooking methods.

The final regression reported in Table 4 is a more formal test of the validity of our regression models. It reports the results of a regression where there are no a priori expectations of a housing quality impact on the dependent variable. We use the number of days in the past 30 in which an occupant reports an injury (*injury days*), defined as a fracture or wound other than a burn. The estimated coefficients for *badlighting*, *badcooking*, and the other statistically significant variables discussed above should in general show no significance in this regression.[14] If this is so, there is evidence that the other equations we estimate are capturing the purported relationships between housing

[13] *Badlighting* is still significant at the 10% level in a 1-tailed test.
[14] This type of test is sometimes referred to as a "zero test" because the estimated coefficients should not be statistically significantly different from 0.

attributes and health. That is, the other regressions are not simply capturing some spurious correlations.

This appears to be the case with our models. *Rural*, *matooke*, *badwalls*, *badlighting*, and *badcooking* are all insignificant in the *injury days* equation.[15] *Crowding* and *hut* remain significant, which seems reasonable in that more occupants per room can lead to more injuries.

**V. Conclusion**

Our findings demonstrate a relationship between objective measures of housing quality and occupant health in a less developed country. Much of the housing-health relationship we show emanates from the lack of ubiquitous access to electricity in Uganda, which requires indoor burning of wood, kerosene, and paraffin for cooking and lighting purposes. Moreover, the impact of inferior cooking methods has the greater detrimental effect. Our results are thus consistent with others who study the relationship between IAP and health. While we do not have data on direct exposure to IAP as do Ezzati and Kammen (2001), Dasgupta et al. (2004a,b), and Pitt et al. (2005), our proxies for poor cooking methods also highlight the importance of IAP in explaining poor health. Our focus goes beyond IAP, however. We also find that crowding, a rural location, and housing type and construction have adverse health consequences.

Our findings contrast with those compiled from developed country data, much of which does not demonstrate a clear link between housing quality and health. The building codes and other statutes that legally require minimum housing standards may largely mitigate the link between housing and health in developed countries. This of

[15] *Indwelling* also remains significant. This appears anomalous.

course is a good thing, and its public health implications should be pursued by an enlightened government that cares about the welfare of its citizens.

The Government of Uganda has recently done much to improve the welfare of the population. Universal primary education now exists, and plans for universal secondary education will soon come to fruition. The Land Act of 2004 for the first time allows women occupancy and inheritance rights to land. Also, sound fiscal and monetary policies and a commitment to a market economy have promoted economic growth rates that reached 8% per year in the 1990s and averaged between 5% and 6% per year since 2000. Moreover, in the past two decades, much of the public health effort in Uganda has been devoted to, among other things, the containment of HIV/AIDS and malaria, and polio eradication. In fact, Uganda was one of the first sub-Saharan countries to mount a public health campaign against HIV/AIDS.

The comparison of our findings to those from countries with enforceable housing quality standards suggests a productive new path for Ugandan public health policymakers to follow. Policies focused on improved housing quality should lead to measurable declines in the incidence and prevalence of respiratory and gastrointestinal illness. For example, public promotion of alternative means of food preparation (e.g., more solar cookers) would appear most efficacious, and further research that studies the cost effectiveness of this type of policy seems warranted.

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**Table 1**
**Frequency of Days Reported Ill**

| Number of | *all sickdays* | | *r-sickdays* | | *g-sickdays* | | *injurydays* | |
|---|---|---|---|---|---|---|---|---|
| | **Freq.** | **% of total** | **Freq.** | **% of total** | **Freq.** | **% of total** | **Freq.** | **% of total** |
| 0 | 1,272 | 17.93% | 4,622 | 65.14% | 6,246 | 88.02% | 6,680 | 94.14% |
| 1-5 | 938 | 13.22% | 520 | 7.33% | 241 | 3.40% | 58 | 0.82% |
| 6-10 | 1,989 | 28.03% | 989 | 13.94% | 326 | 4.59% | 107 | 1.51% |
| 11-15 | 1,259 | 17.74% | 493 | 6.95% | 164 | 2.31% | 85 | 1.20% |
| 16-20 | 409 | 5.76% | 122 | 1.72% | 37 | 0.52% | 38 | 0.54% |
| 21-25 | 289 | 4.07% | 103 | 1.45% | 22 | 0.31% | 33 | 0.47% |
| 26-30 | 940 | 13.25% | 247 | 3.48% | 60 | 0.85% | 95 | 1.34% |
| 0 - 30 | 7,096 | 100% | 7,096 | 100% | 7,096 | 100% | 7,096 | 100% |

**Table 2**
**Variable Definitions and Summary statistics (n = 7,096)**

| Variable | Definition | Mean | Standard devitation | Expected sign |
|---|---|---|---|---|
| *all sickdays* | Number of days in past 30 the most ill person in the dwelling reports illness from one or more maladies | 10.957 | 9.483 | dependent variable |
| *r-sickdays* | Number of days in past 30 the most ill person in the dwelling reports respiratory illness | 3.930 | 7.108 | dependent variable |
| *g-sickdays* | Number of days in past 30 the most ill person in the dwelling reports diarrhea | 1.202 | 4.113 | dependent variable |
| *injurydays* | Number of days in past 30 the most frequently injured person reports an injury other than a burn | 0.914 | 4.319 | dependent variable |
| *crowding* | Number of people per room | 1.658 | 1.234 | + |
| *indwelling* | Indicator variable=1 if dwelling is an independent house, 0 | 0.580 | 0.494 | - |
| *hut* | Indicator variable=1 if dwelling is a single room detached structure, 0 otherwise | 0.234 | 0.423 | + |
| *badroof* | Indicator variable=1 if roof is made of mud, wood, or asbostos, 0 otherwise | 0.003 | 0.050 | + |
| *badwalls* | Indicator variable=1 if walls are made of thatch, straw, or mud and poles, 0 otherwise | 0.425 | 0.494 | + |
| *badwater* | Indicator variable=1 if water source is a bore hole, rain, or any other unprotected source, 0 otherwise | 0.299 | 0.458 | + |
| *badtoilet* | Indicator variable=1 if toilet is other than a flush toilet, 0 otherwise | 0.979 | 0.145 | + |
| *badlighting* | Indicator variable=1 if source of lighting is kerosene, wood, paraffin, or gas lantern, 0 otherwise | 0.884 | 0.320 | + |
| *badcooking* | Indicator variable=1 if cooking fuel is firewood, charcoal, kerosene, or parafffin, 0 otherwise | 0.970 | 0.172 | + |
| *malehead* | Indicator variable=1 if the household head is male, 0 otherwise | 0.728 | 0.445 | ? |
| *aveage* | Average age in years of all household members | 22.394 | 12.151 | + |
| *matooke* | Percentage of total food consumption devoted to matooke, a staple with little nutritional value | 0.097 | 0.144 | + |
| *protein* | Pecentage of total food consumption devoted to meat and eggs | 0.109 | 0.119 | - |
| *rural* | Indicator variable=1 if dwelling is not in an urban area, 0 otherwise | 0.773 | 0.419 | + |
| *expenditures* | Total monthly household spending on non-durable goods net of health spending (thousands of Ush) | 48.625 | 84.633 | - |
| $region_j$ | Set of 3 binary variables indicating region in which the household is located (Central omitted) | ----- | ----- | ----- |
| *surveymonthj* | Set of 11 binary variables indicating the month in which the survey was conducted (January omitted) | ----- | ----- | ----- |

**Table 3**

**Dependent Variable: *all sickdays***

| Variable | Poisson Coefficient [S.E.][a] | Poisson I.R.R.[b] | Negative Binomial Coefficient [S.E.][a] | Negative Binomial I.R.R.[b] |
|---|---|---|---|---|
| *crowding* | **0.0538*** [0.0087]** | **1.0553** | **0.0690*** [0.0100]** | **1.0715** |
| *indwelling* | **0.2454*** [0.0361]** | **1.1288** | **0.2539*** [0.0376]** | **1.1335** |
| *hut* | **0.2800*** [0.0423]** | **1.1258** | **0.2840*** [0.0438]** | **1.1277** |
| *badroof* | 0.1210 [0.2335] | 1.0061 | 0.1029 [0.2400] | 1.0052 |
| *badwalls* | **0.0727*** [0.0231]** | **1.0366** | **0.0937*** [0.0250]** | **1.0474** |
| *badwater* | 0.004 [0.0231] | 1.0018 | -0.0028 [0.0238] | 0.9987 |
| *badtoilet* | 0.0954 [0.0839] | 1.0139 | 0.1279 [0.0874] | 1.0187 |
| *badlighting* | **0.2147*** [0.0477]** | **1.0711** | **0.2010*** [0.0485]** | **1.0664** |
| *badcooking* | **0.5444*** [0.1096]** | **1.0980** | **0.5736*** [0.1057]** | **1.1036** |
| *malehead* | **-0.0431* [0.0229]** | **0.9810** | **-0.0579** [0.0239]** | **0.9746** |
| *aveage* | **0.0020** [0.0010]** | **1.0020** | **0.0020* [0.0010]** | **1.0020** |
| *matooke* | 0.1034 [0.0826] | 1.1090 | **0.1404* [0.0835]** | **1.1507** |
| *protein* | -0.0806 [0.0879] | 0.9226 | -0.0393 [0.0886] | 0.9615 |
| *rural* | **0.1328*** [0.0309]** | **1.0572** | **0.1449*** [0.0326]** | **1.0626** |
| *expenditures* | **0.0335*** [0.0060]** | **1.0340** | **0.0382*** [0.0078]** | **1.0389** |
| *constant* | **-0.5669* [0.3490]** | **---** | **-0.9015** [0.4364]** | **---** |
| γ | | | 0.9999 [0.0247] | |

| | | | |
|---|---|---|---|
| n = | 7,096 | n = | 7,096 |
| Log Likelihood = | -41,935.84 | Log Likelihood = | -24,202.66 |
| Goodness of fit $\chi^2$ = | 59,325.81[c] | Dispersion $\chi^2$ = | 35,466.2[e] |
| p-value = | 0.00 | p-value = | 0.00 |
| Wald $\chi^2$ = | 437.39[d] | Wald $\chi^2$ = | 417.56[d] |
| p-value = | 0.00 | p-value = | 0.00 |

[a] Standard errors clustered at the household level.

[b] Shows the relative effect of a unit (or std. dev.) change in the regressor on $\mu$ = E(*dep. var.*).

[c] Tests Ho: *all sickdays* is Poisson-distributed

[d] Tests Ho: $\alpha = \beta_j = 0$

[e] Tests Ho: $\gamma = 0$ (no overdispersion)

NOTE: all regressions include fixed effects for survey month and region, * identifies statistical significance at the 10% level, ** identifies statistical significance at the 5% level, and *** identifies statistical significance at the 1% level.

**Table 4**
**Negative Binomial Regressions**

| | Dependent Variables | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ***all sickdays*** | | ***r-sickdays*** | | ***g-sickdays*** | | ***injurydays*** | |
| **Variable** | I.R.R.[a] | [S.E.][b] | I.R.R.[a] | [S.E.][b] | I.R.R.[a] | [S.E.][b] | I.R.R.[a] | [S.E.][b] |
| *crowding* | **1.0715*** ** | 0.0010 | **1.0900*** ** | 0.0210 | **1.2232*** ** | 0.0441 | **1.1745*** ** | 0.0557 |
| *indwelling* | **1.1335*** ** | 0.0376 | **1.1478*** ** | 0.0823 | **1.1569*** | 0.1761 | **1.3574*** ** | 0.2307 |
| *hut* | **1.1277*** ** | 0.0438 | **1.1551*** ** | 0.0995 | **1.3184*** ** | 0.1990 | **1.3485*** ** | 0.2585 |
| *badroof* | 1.0052 | 0.2400 | 0.9927 | 0.6932 | 0.9342 | 0.9056 | 0.9981 | 0.9999 |
| *badwalls* | **1.0474*** ** | 0.0250 | **1.0531*** | 0.0538 | **1.1629** ** | 0.1251 | 1.0529 | 0.1478 |
| *badwater* | 0.9987 | 0.0238 | 1.0176 | 0.0517 | 0.9920 | 0.1191 | 1.0188 | 0.1448 |
| *badtoilet* | 1.0187 | 0.0874 | 1.0010 | 0.1744 | 1.0460 | 0.3826 | 1.1040 | 0.6015 |
| *badlighting* | **1.0664*** ** | 0.0485 | **1.0730** ** | 0.1041 | 1.1181 | 0.2280 | 1.0853 | 0.2613 |
| *badcooking* | **1.1036*** ** | 0.1057 | **1.1949*** ** | 0.2426 | **1.2970** ** | 0.6219 | 1.0262 | 0.4716 |
| *malehead* | **0.9746** ** | 0.0239 | **0.9569*** | 0.0517 | 1.0244 | 0.1158 | 1.0161 | 0.1441 |
| *aveage* | **1.0020*** | 0.0010 | 1.0000 | 0.0023 | **0.9689*** ** | 0.0056 | 1.0004 | 0.0059 |
| *matooke* | **1.1507*** | 0.0835 | 1.0622 | 0.2006 | 0.5504 | 0.4512 | 0.8268 | 0.4859 |
| *protein* | 0.9615 | 0.0886 | 0.7789 | 0.1969 | **0.4762*** | 0.4257 | 0.7766 | 0.5564 |
| *rural* | **1.0626*** ** | 0.0326 | 1.0348 | 0.0708 | **1.1315** ** | 0.1470 | 1.0709 | 0.1987 |
| *expenditures* | **1.0389*** ** | 0.0078 | 1.0283 | 0.0180 | 1.0224 | 0.0352 | **1.0939** ** | 0.0427 |
| $\gamma$ | 0.9999 | 0.0248 | 6.9558 | 0.1772 | 23.5843 | 0.9602 | 65.0623 | 3.3714 |
| n | 7,096 | | 7,096 | | 7,096 | | 7,096 | |
| Log Likelihood | -24,202.66 | | -13,652.87 | | -5,582.82 | | -3,306.71 | |
| Wald $\chi^2$ | 417.56[d] | | 171.81[d] | | 208.2[d] | | 63.54[d] | |
| p-value | 0.00 | | 0.00 | | 0.00 | | 0.00 | |

[a] Shows the relative effect of a unit (or std. dev.) change in the regressor on $\mu$ = E(*dep. var.*).
[b] Standard errors clustered at the household level.
[c] Tests Ho: no overdispersion ($\gamma = 0$).
[d] Tests Ho: $\alpha = \beta_j = 0$
NOTE: all regressions include fixed effects for survey month and region, * identifies statistical significance at the 10% level, ** identifies statistical significance at the 5% level, and *** identifies statistical significance at the 1% level.