

Working Paper

Prevention, Resilience, Efficiency, and Protection for workers in industrial agriculture in a changing climate (PREP):
Baseline results from a household panel survey of the socioeconomic conditions experienced by agricultural workers
in Chichigalpa, Nicaragua

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Abstract

Objective

Our purpose with this study is to examine the socioeconomic outcomes associated with chronic kidney disease not related to well-known risk factors (CKDnt) in four communities in Chichigalpa, Nicaragua that are home to a substantial number of sugarcane workers.

Methods

We employed a cluster-based systematic sampling design to identify differences in outcomes between those households affected directly by CKDnt and those that are not.

Results

Overall, we find that approximately a third of households surveyed had a household member diagnosed with CKDnt. Eighty percent of CKDnt households reported that the head of the household had been without work for the last 6 months or more, compared to 61 percent of non-CKDnt households. Non-CKDnt households took in more than double the earnings income than CKDnt households (C\$ 51,845 and C\$ 24,295, respectively). Nonetheless, on average, CKDnt households' total income exceeded that of non-CKDnt households due to Nicaragua's national INSS Social Security payments to CKDnt households, suggestive of a substantial economic burden on the state resulting from the disease. Households headed by widows or widowers who are widowed as a result of CKDnt demonstrate distinct deficits in total income when compared to either non-widowed households or to households widowed by causes other than CKDnt.

Conclusions

Despite strong similarities in terms of demographic characteristics, and despite residing in the same communities with similar access to the available resources, households experiencing CKDnt exhibit distinct and statistically significant differences in important socioeconomic outcomes when compared to non-CKDnt households.

1. Summary

- 1.1. What is already known on this topic:** Chronic kidney disease among laborers is driven by strenuous work in high environmental temperatures, and its prevalence is increasing among agricultural workers, typically men in their prime earning years.
- 1.2. What this study adds:** Our study begins to fill gaps in the occupational health literature by examining the links between health shocks, such as chronic kidney disease, and household and community economic health.
- 1.3. How this research might affect research, practice, or policy:** By examining the relationship between chronic kidney disease and household and community economic health, we provide researchers, practitioners, and policymakers with a more complete perspective on the impacts of the disease, extending beyond health effects.

2. Introduction

For over three decades, an epidemic of chronic kidney disease (CKD), not related to well-known risk factors such as diabetes and hypertension, and so known as CKD of non-traditional origins (CKDnt) or Mesoamerican Nephropathy (MeN), has been detected among agricultural and other heavy laborers in Mesoamerica, in particular sugarcane workers. There is a growing body of evidence that strenuous work in high environmental temperatures without sufficient rest or hydration is an important driver of the disease.

In 2020, the National Science Foundation, the National Oceanic and Atmospheric Administration, and the Belmont Forum funded the Prevention, Resilience, Efficiency, and Protection (PREP) program. PREP has three primary foci:

- measuring the immediate and long-term impact that a workplace intervention, specifically aimed at providing sufficient water, scheduled shaded rest, as well as improved sanitation and ergonomics (WRS), has on sugar cane workers' health (kidney health and heat-related symptoms) and productivity;
- measuring the economic and social impacts on individuals, families, communities, and health systems affected by CKDnt, and whether PREP's intervention aids in resilience, including mitigating migration pressures; and
- conducting an analysis of public health policies to understand what policies, or their absence, have contributed to the disease, while also investigating what policies are required to effectively address it.

This report presents baseline results¹ from a household survey employed to address the second of these foci, comparing the difference in economic and social conditions between households in four communities in Chichigalpa, Nicaragua affected by CKDnt with those that are not affected by the

¹ Subsequent rounds of data collection were completed in late 2022, with analysis of longitudinal outcomes scheduled for completion in August of 2023.

disease.² This component of PREP principally consists of multiple rounds of primary data collection via a household survey instrument adapted from UNICEF's Multiple Indicator Cluster Surveys (MICS) tool and USAID's Resilience Evaluation, Analysis, and Learning (REAL) survey tool³. The adapted instrument is designed to distinguish among the household consequences of disease burden, including those related to income and savings, food consumption, labor supply, and human capital accumulation⁴.

Our primary research question with this component of the study is: do differences in the CKDnt-related health status of households account for observable differences in earnings, income, savings, education, and other socioeconomic outcomes? The following presents our analysis of our baseline survey round, completed in December of 2021.

The existing literature on the relationship between occupational health and longer-term economic outcomes presents significant gaps in terms of studies that quantify the socioeconomic impact of CKDnt on households in which primary wage earners become ill during their prime earning years. While the causes of CKDnt, its geographic concentration, and the populations the disease affects are relatively well-understood, we are less certain about the household and community's ability to adapt to the disease. Absent a clearer understanding of the relationship between CKDnt and socioeconomic and resilience outcomes, public health professionals, policymakers, and communities seeking to address CKDnt cannot fully evaluate the impact of their efforts. This study partially addresses this gap in the literature.

PREP contributes to the relatively limited body of research on the economic impact of chronic disease at the household level. The growing prevalence of non-traditional kidney disease among agricultural populations has gained international attention from public health researchers, government officials, and advocacy groups focused on preventing occupational illness [1]. The disease presents a challenge for employers, governments, and those communities that must bear its social and financial burdens [2-3]. CKD is prevalent in both the developed and developing world, though the causes of the disease differ, with risk factors associated with the traditional development of CKD stemming from other chronic issues such as cardiovascular disease and hypertension [4]. However, a strong case has been made for links between heat stress and the development of CKDnt, particularly in the developing world [5-6].

A range of epidemiologic studies, including cross-sectional, cohort-based, and GIS studies, using both experimental and qualitative methods, have detected reduced kidney function in populations working under extreme heat conditions [7]. For example, a study employing GIS mapping techniques to track temperature burden in Central America identified a correlation between high average yearly temperatures and CKDnt [8]. This association between heat and kidney disease is also consistent across regions where workers are routinely exposed to high levels of heat stress. Along with Central America, studies have identified pockets of the disease in Southeast Asia and India [9].

Most CKDnt sufferers are young men, with a relatively high percentage of them developing the disease in their twenties and thirties [9-10]. When these young men are also the primary, or sole, wage-earners for a family, the economic consequences can be assumed to be profound. In their framework,

² This component of the study is carried out in collaboration with the La Isla Network partners, including an international team of epidemiologists and medical doctors engaged with the Adelante initiative.

³ This article presents the socioeconomic outcomes from the baseline round of data collection. Future articles will include analysis of resilience outcomes.

⁴ These findings will also be incorporated into the Department of Labor Bureau of International Labor Affairs' PREP 4 Change program, which extends these approaches to three additional Central American countries: El Salvador, Guatemala and Honduras.

Suhrcke et al delineated among three main types of economic consequences stemming from chronic disease: those related to consumption and savings, labor supply and productivity effects, and education and human capital accumulation. They further define the consumption and savings consequences to include effects on a household's "ability to hold consumption levels constant in the face of 'health shocks' from disease" [11, p.19], as well as costs associated with treating the disease. Suhrcke et al also note that some evidence does exist for a negative impact of illness across each of these three main types of economic outcomes, but that there remains a need for additional studies that are based on survey data "that combine both relevant chronic disease proxies and the usual socioeconomic and demographic data" [11, p. 25].

In their study of the economic impacts of health on earnings in seven Latin American Countries, Savedoff and Schultz conclude that healthier individuals receive higher earnings, and that reduced exposure to disease, among other factors, is "associated positively with the health of the adults and also with greater individual income-generating capacity" [12, p.12]. In his study of health shocks on Vietnamese households, Wagstaff found that health shocks may be associated with increases in unearned income that partially offset reductions in earned income, as well as with large increases in medical spending and reductions in spending on food [13].

In the following, Section 2 covers the methodology employed. Section 3 presents selected findings related specifically to household demographics, income and earnings, expenditures, and differences between the two household types. Section 4 focuses on findings related to employment. Section 5 presents selected findings related to health outcomes and differences between CKDnt and non-CKDnt households. Section 6 presents findings from our subpopulation analysis of widows. Section 7 contains the discussion of the study's findings and limitations and our concluding remarks.

3. Methodology

3.1. Sampling strategy

We employed a disproportionate stratified systematic sampling tool to retrieve comparable data from CKDnt and non-CKDnt households in four communities in Chichigalpa. Our sample frame included 1,961 home structures, of which 1,851 were eligible to participate in the household survey after unoccupied structures were removed from the household list. We then systematically randomized households to select 600 households from the eligible sample list. To ensure substantial representation in the data for CKDnt households, we drew 80% of our sample from the two communities that were known locally to have a relatively higher number of households with one or more members working in the agricultural sector. We drew the other 20% of our sample from the two communities known to contain workers working across a relatively equal distribution of sectors. All analysis was done in Stata 17.

3.2. Survey design and timeline

The questionnaire combined questions adapted from UNICEF's MICS, as well as from USAID's REAL methodology, and includes a total of 244 questions divided into 23 modules that covered 6 topics including family information, demographics, income, employment, CKDnt (shocks), and resilience.⁵

⁵ For the purposes of this report, we are reporting only the baseline socioeconomic outcomes. In future reports, we will present our panel data analyses, as well as our examination of differences in resilience outcomes between household types.

Baseline data collection for the longitudinal study began in May of 2021 with the GIS mapping of a household sample frame. In total, 609 completed questionnaires were completed.⁶

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⁶ The additional 9 surveys administered were due to some miscommunication amongst field enumerators. We opted to include the additional surveys in the analysis after reviewing and removing potential duplicates or incomplete questionnaires.

4. Baseline Survey Results on Household Demographics

4.1. Household characteristics

4.1.1. Demographics

Households reported an average size of 4 members with 2.2 working-age adults (between ages 18 and 65). The vast majority of households reported having electricity. A majority of households reported owning their homes. Of the 609 households surveyed, a little under a third reported having a household member diagnosed with CKDnt (n=190). The household characteristics presented in Figure 1 were similar for households with and without CKDnt members.

Figure 1. Demographic characteristics of the study population

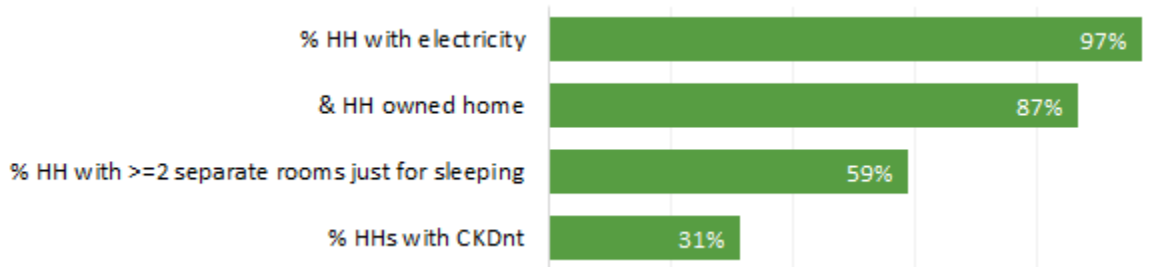
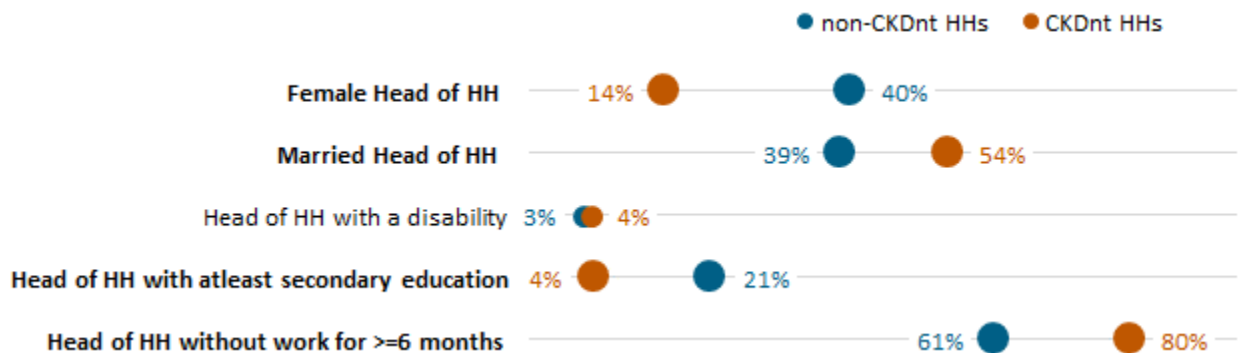


Figure 2 illustrates that CKDnt households had a significantly lower proportion of female heads of households and a significantly higher proportion of married heads of households compared to non-CKDnt households. Possible reasons for this finding are that the lower proportion of female heads of households among CKDnt households potentially reflects a higher rate of combined families living in a single household after the death of the male head of household, or that, simply, non-CKDnt households are headed by widows (examined in greater detail in Section 7 below). Notably, a significantly higher proportion of CKDnt households reported that the head of household had been without work for the last 6 months or more (80% vs. 61%).

Figure 2. Demographics characteristics by CKDnt status⁷



⁷ Bolded variables indicate statistical significance at the 95% level.

4.1.2. Household income and sources

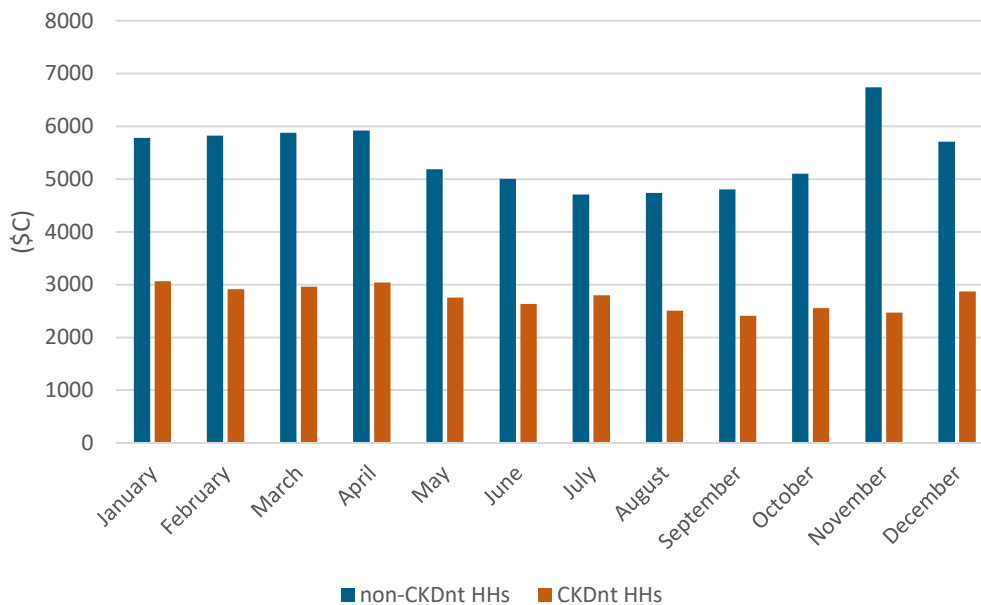
CKDnt households and non-CKDnt households reported similar annual household incomes overall, with households reporting an annual income of about C\$ 74,000 (or US \$2,070), as shown in Table 1. However, examining incomes by type indicates that CKDnt households gained significantly less income from employment earnings compared to non-CKDnt households.

Table 1. Annual household earnings

Annual income	Non-CKDnt HHs (C\$)	CKDnt HHs (C\$)
Income from other sources	20,152	51,512
Income from earnings from employment	51,845	24,295
Total income	71,997	75,807

Figure 3 below demonstrates the differences in reported employment earnings for CKDnt and non-CKDnt households. Monthly earnings illustrate the economic patterns of the community as they correspond with Nicaragua’s sugarcane harvest season (November to May). Non-CKDnt households display a defined uptick in earnings during the harvest season, while CKDnt households do not, corresponding with the significantly larger proportion of CKDnt households reporting that the primary wage earner has been without work in the six months prior to the survey.

Figure 3: Average Employment Earnings Trends by Month



As with Wagstaff’s findings from his study into health shocks and economic outcomes in Vietnam [13], our examination of income from other sources, Table 2, indicates that CKDnt households obtained the bulk of their unearned income from Nicaragua’s INSS Social Security payments.

Table 2. Elements of average monthly household income

Monthly income from other sources	Non-CKDnt HHs (C\$)	CKDnt HHs (C\$)
Pension from another Source (not INSS)	412	165
INSS Social Security	975	3,840
Income from earnings from employment	51,845	24,295
Savings, interest, or other investment Income	73	18
Cash gifts	75	43
Lottery/gambling winnings	7	2
Rental income from non-agricultural land rental	5	2
Rental income from apartment/house rental	5	0
Income from household agricultural asset sales	28	46
Income from household non-agricultural asset sales	89	177

Just over three-quarters of CKDnt households (n=147) report receiving income from INSS Social Security compared to only one quarter of non-CKDnt households. As shown in Table 3, when we examine income stratified by INSS Social Security receipt, we note striking differences. CKDnt households that receive INSS Social Security reported similar annual household incomes overall to non-CKDnt households that receive INSS Social Security, reporting an annual income of about C\$ 85,000. However, CKDnt households that do not receive INSS Social Security report a much lower annual household income compared to non-CKDnt households that do not receive INSS Social Security (C\$ 43,876 vs. C\$ 69,550 respectively). This points to the economic impact for families who do not qualify for INSS due to the need to work 230 weeks in the formal sector with at least 26 weeks of risk exposure prior to a CKDnt diagnosis in order to qualify for compensation, thereby significantly limiting who has access to remediation, especially those who may become sick while working in informal sector.

Table 3. Annual household earnings stratified by social security receipt

	n	Income from other sources (C\$)	Income from earnings from employment (C\$)	Total income (C\$)
Non-CKDnt HHs with no INSS Social Security	315	9,121	60,429	69,550
Non-CKDnt HHs receiving INSS Social Security	102	56,786	29,383	86,169
CKDnt HHs with no INSS Social Security	43	11,667	32,210	43,876
CKDnt HHs receiving INSS Social Security	147	62,767	20,794	83,561

4.2. Household expenditures

CKDnt households and non-CKDnt households reported similar monthly expenditures overall, as shown in Table 4, with households spending about C\$5,900 (approximately \$167 USD) each month. However, CKDnt households spent significantly less on education, despite slightly larger households (3.9 members vs. 3.5 in non-CKDnt households), and more on medicines than non-CKDnt households, perhaps suggesting that either CKDnt households have reduced education expenses due to children leaving school to enter the workforce, or education expenses have been shifted to cover medicine expenses, or some combination.

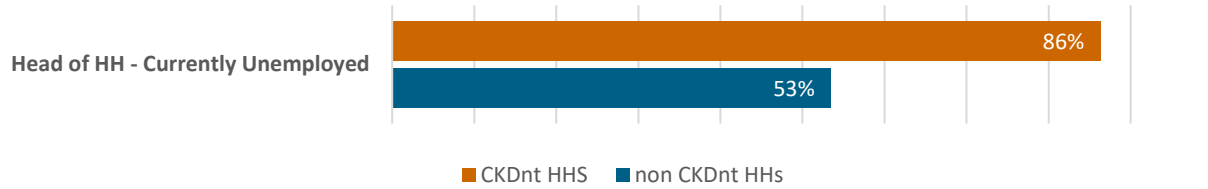
Table 4. Average monthly household expenditures

Monthly expenses	Non-CKDnt HHs (C\$)	CKDnt HHs (C\$)
Electricity	300	272
Water	105	97
Education	831	713
Food	3,636	3,787
Medicine	395	559
Clothing	466	436
Other	123	70
Overall	5,856	5,934

5. Baseline Survey Results on Employment

Figure 5 illustrates that just over three-fourths of respondents reported that the head of household was currently unemployed (n=455). Among these households, 86% of CKDnt households reported that the head of household was unemployed, compared to only 53% of non-CKDnt households.

Figure 5. Employment status



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6. Baseline Survey Results on CKDnt and Health

As shown in Figure 6, of the 190 households with CKDnt, the majority reported receiving medical care and taking medications for kidney disease. About half reported using traditional medicine to treat disease, while less than a fifth reported receiving hemodialysis.

Figure 6. CKDnt treatments

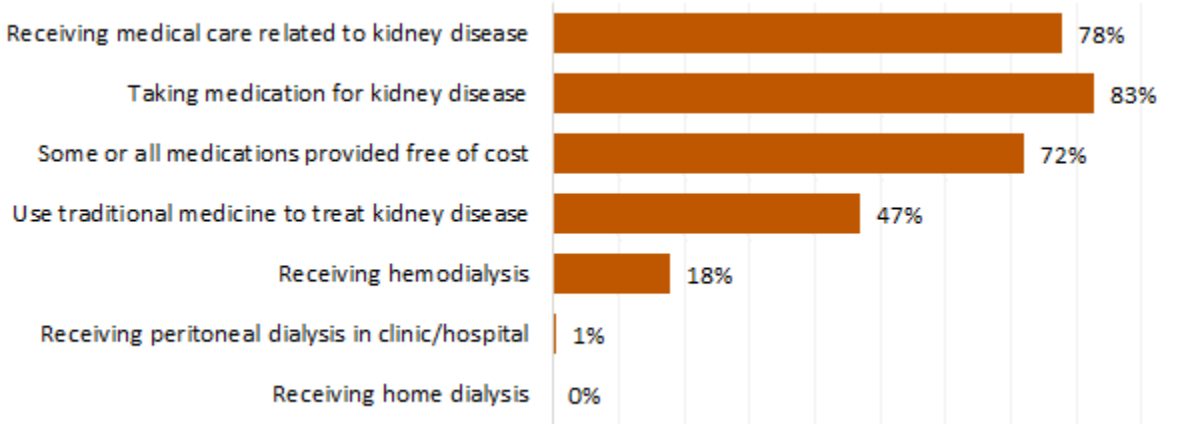
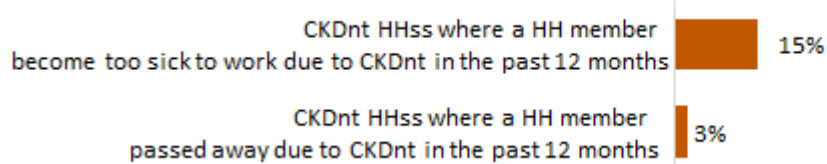


Figure 7 illustrates that among the 190 CKDnt households, 29 households (15 percent) reported that a household member became too sick to work in the past 12 months, and 5 households (3 percent) reported that a household member passed away due to CKDnt in the past 12 months.

Figure 7. CKDnt health outcomes



7. Widowed Households

The following presents additional subpopulation analysis on demographic, employment, and earnings outcomes for households headed by a widow/widower, as households headed by widows who have lost a household member due to CKDnt. We confirmed Widow/non-Widow status for 593 of our baseline respondents. Of those, 87 heads of household (16.5%) indicated that they are widowed⁸, and, of those, 67 (80%) indicated that their household had lost a member due to CKDnt. The majority of widowed households (74%) lost their spouse/partner over 5 years prior to the time the survey was administered, and 17 (20%) lost their spouse/partner within the last 5 years. Of the households headed by widows, 40 indicated they were receiving some kind of pension as a result of their widow status (47%).

⁸ This figure is nearly triple the 5.5% widowhood rate for Nicaragua as a whole, as reported in the country's 2015 Census data.

Tables 5 and 6 provide a breakdown of average income by income types and by widowhood groups. The groups are defined by whether or not widowhood was caused by CKDnt being present in the household, and by widowhood length by cause of widowhood.

Table 5. Income and sources by widow and CKDnt household status

Household Status	Income from other sources (C\$)	Income from employment (C\$)	Total income (C\$)	Counts (n)
Non-Widowed/No CKDnt Present	18,097	57,688	75,785	340
Non-Widowed/CKDnt Present	53,151	20,088	73,239	166
Widowed/No CKDnt present	58,178	20,408	78,586	12
Widowed/CKDnt Present* ⁹	**	**	**	**
Widowed by CKDnt/No CKDnt Present	27,187	26,817	54,004	56
Widowed by CKDnt/CKDnt Present	33,982	30,973	64,955	11

Table 6. Income by source and duration of widowhood

Duration of widowhood	Income from other sources	Income from employment	Total income	Counts (n)
Non-Widowed	29,608	44,898	74,506	506
Widowed < 5 yrs ¹⁰	**	**	**	**
Widowed ≥ 5 yrs	55,470	33,408	88,878	12
Widowed by CKDnt < 5 yrs	29,576	30,173	59,749	17
Widowed by CKDnt ≥ 5 yrs	27,869	26,590	54,459	50

These sets of tables provide some insight into the effect of the cause of widowhood on household income. Households widowed by CKDnt take in substantially less income than non-widowed households. Given that the bulk of other source incomes come from INSS benefits (as shown in Tables 2 and 3), it appears there might be some gap in coverage for households directly affected by CKDnt. In

Tables 7 and 8 examine widowhood status and duration of widowhood by rates of female heads of household, head of household's age and employment status, the average number of household members

⁹ Data for "Widowed/CKDnt present" category is suppressed due to small cell size.

¹⁰ Data for "Widowed < 5 yrs" category is suppressed due to small cell size.

who are working, and whether or not the head of household is receiving a pension due to her status as a widow.

Table 7. Demographics, employment, and INSS receipt by widowhood status

Household Status	Rate of Female Heads of Household	Ave. Age of Household Head	Household Head Employed	Ave. # employed in HH	HH Receiving Pension due to Head's Widow Status	Counts (n)
Non-Widowed/No CKDnt Present	30.0%	41	56%	1	n/a	340
Non-Widowed/CKDnt Present	8.4%	46	15%	0.5	n/a	166
Widowed/No CKDnt present	75.0%	72	0%	0.4	33.3%	12
Widowed/CKDnt Present	40.0%	66	0%	1.2	20.0%	**
Widowed by CKDnt/No CKDnt Present	100.0%	59	7%	0.6	51.8%	56
Widowed by CKDnt/CKDnt Present	90.9%	59	18%	1	45.5%	11

Table 8. Demographics, employment, and INSS receipt duration of widowhood status

Household Status	Rate of Female Heads of Household	Ave. Age of Household Head	Household Head Employed	Ave. # employed in HH	HH Receiving Pension due to Head's Widow Status	Count (n)
Non-Widowed	23%	43	42.4%	0.81	n/a	506
Widowed < 5 yrs	**	**	**	**	**	**
Widowed >= 5 yrs	75%	67	0.0%	0.75	25%	12
Widowed by CKDnt < 5 yrs	94%	51	11.8%	0.71	59%	17
Widowed by CKDnt >= 5 yrs	100%	62	8.0%	0.58	48%	50

These demographic indicators demonstrate that household heads widowed by CKDnt are significantly younger than those who are widowed by other causes. There also appears to be a relationship between employment status and CKDnt presence in the household when looking at households with widow/widowers; it appears that widowed households with a CKDnt sufferer currently living in the household have a slightly higher number of employed compared to widowed households with no CKDnt present, possibly as a result of the CKDnt sufferer attempting to work in order to maintain income for the family. We also note that the percentage of households indicating that they are receiving a pension due to their widow status decreases by about 19% for households that have been widowed by CKDnt for over 5 years compared to those widowed by CKDnt for fewer than 5 years.

8. Concluding Remarks

8.1 Strengths and limitations

Our study measures the socioeconomic effect of CKDnt on households by comparing these households to households not affected by CKDnt. The research design and subsequent data collection efforts in underexamined communities in Chichigalpa represent a first-of-its-kind study of how CKDnt contributes to a loss in income from employment earnings, resulting in substantial state investment in terms of INSS payments to affected households, and contributes to nearly tripling the national widowhood rate. We will compare subsequent rounds of data collection to these baseline findings to examine how the differences between the two groups change over time. Importantly, our study begins to fill gaps in the occupational health literature by examining the links between health shocks, such as CKDnt, and household economic health. Our study is limited in certain, important respects. Primarily, we were able to complete only two rounds of data collection due to the difficulties in fielding a study during the Covid pandemic and its related travel restrictions; in order to fully understand the causal relationship between CKDnt and socioeconomic outcomes, a significantly longer timeframe is needed. While this study began after Adelante’s WRS intervention had been implemented, making a typical

impact evaluation impracticable, we are able to establish a baseline against which we will be able to measure change in socioeconomic and resilience outcomes over time. Finally, missing data on several key variables of interest, limit our analysis.

Despite strong similarities in terms of demographic characteristics, and despite residing in the same communities with similar access to the available resources, households experiencing CKDnt exhibit distinct and statistically significant differences in important socioeconomic outcomes when compared to non-CKDnt households. Follow-up survey rounds will measure changes in socioeconomic indicators over time, as well as include findings related to household and community resilience data.

What can be asserted now is that there are significant costs associated with treating individuals with CKDnt, and supporting those who have lost someone due to CKDnt, and that these costs are borne, in large part, by the state through INSS payments. At present, these payments enable CKDnt households to maintain a rough parity in terms of income with non-CKDnt households if they qualify for assistance.

Moreover, it is unlikely that the burden borne by the state in caring for workers suffering from a potentially preventable disease is sustainable, pointing to the need for increased surveillance of labor practices and the implementation of effective interventions. Based on our estimate of the community prevalence and the per household INSS amount paid to shore up already meagre household incomes of CKDnt sufferers, the state is making annual expenditures approximately C\$ 46,080 (or USD \$1,280) per household. Prevention of CKDnt, as demonstrated by other studies [15], costs a fraction of the per capita INSS annual expenditures on care for CKDnt patients, with a WRS intervention costing approximately C\$ 6,048 (or USD \$168 per worker) annually. These estimates suggest that the benefits to the state, never mind the individuals, of investing in prevention of CKDnt would far exceed the costs.

With upcoming analyses, we hope to further fill the gap in the knowledge concerning the relationship between entrenched poverty and chronic diseases like CKDnt, a disease that is likely preventable with relatively modest up-front occupational health investments that have, demonstrably [15] yielded significant positive return on investment.

9. Data availability statement

The data collection process is described in the method section of this article. Access to primary data is restricted by the conditions specified in the Internal Review Board approval obtained from the University of Texas at Austin. Details from the analysis may be obtained from the corresponding author on request.

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