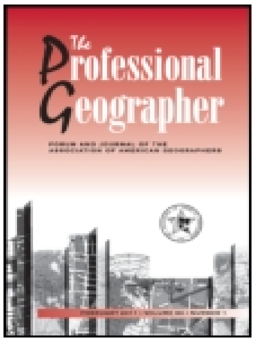

The Professional Geographer

ISSN: 0033-0124 (Print) 1467-9272 (Online) Journal homepage: http://www.tandfonline.com/loi/rtpg20

Household Water Insecurity in the Global North: A Study of Rural and Periurban Settlements on the Texas–Mexico Border

Wendy Jepson & Emily Vandewalle

To cite this article: Wendy Jepson & Emily Vandewalle (2016) Household Water Insecurity in the Global North: A Study of Rural and Periurban Settlements on the Texas–Mexico Border, The Professional Geographer, 68:1, 66-81, DOI: 10.1080/00330124.2015.1028324

To link to this article: http://dx.doi.org/10.1080/00330124.2015.1028324

Published online: 21 May 2015.

Household Water Insecurity in the Global North: A Study of Rural and Periurban Settlements on the Texas–Mexico Border

Wendy Jepson and Emily Vandewalle
Texas A&M University

This article examines household-level characteristics that predict water insecurity in low-income rural and periurban communities on the Texas–Mexico border. We employ two logistic regression models (binary and ordered) to identify household characteristics that are more likely to result in water insecurity. Our analyses yielded unexpected findings: Whereas socioeconomic factors are weak predictors, immigration status of household members is a significant variable that contributes to household water insecurity. Policymakers need to pay more attention to marginalized communities as "universal" water access still leaves populations without adequate, reliable, and affordable water in the Global North. **Key Words: colonias, household water security, logistic regression, Texas, water resources.**

本文检视预测德州—墨西哥边界上，低收入的农村与半城市化社区用水不安全的家户层级特徵。我们运用两个罗吉特迴归模型（二元与序位），指认更有可能导致用水不安全的家户特徵。我们的分析，得到了不被预期的发现：社会经济因素是较弱的指标，反之，家户成员的移民身份，则是导致家户用水不安全的显着变项。政策制定者必须更加关注边缘化的社群，因为所谓 "普世性" 的水资源取得管道，仍然让诸多全球北方的人口未能获得适宜、可靠且可负担的用水。 **关键词: 殖民地，家户用水安全，罗吉特迴归，德州，水资源。**

Este artículo examina, en el área limítrofe Texas-México, las características que a nivel de hogares predicen problemas de inseguridad hídrica en comunidades rurales y periurbanas de bajos ingresos. Empleamos dos modelos de regresión logística (binario y ordenado) para identificar las características de los hogares más propensos a ser afectados por la inseguridad hídrica. Nuestros análisis generaron resultados inesperados: En tanto que los factores socioeconómicos son predictores débiles, el estatus de inmigración de los miembros del hogar es una variable significativa que contribuye a la inseguridad hídrica del hogar. Los encargados de formular políticas deben poner mayor atención a las comunidades marginadas, por cuanto el acceso "universal" al agua todavía deja poblaciones en el Norte Global sin agua adecuada, confiable y económicamente accesible. **Palabras clave: colonias, seguridad hídrica para el hogar, regresión logística, Texas, recursos hídricos.**

The pervasive view that households in developed countries have universal, indoor plumbing and secure water belies everyday experiences in low-income and marginalized communities, where access to and benefit from adequate, affordable, and safe drinking water are daily struggles. In the United States, more than 600,000 households, or approximately 1.5 million people, live without complete plumbing facilities (American Communities Survey 2012). Many are homeless or belong to migrant or economically distressed populations. In Europe, Roma settlements lack access to safe water and sanitation (Harper, Steger, and Filčák 2009; Laurent 2011). For economically distressed households with access to water infrastructure, water service might not be affordable and water reliability and quality might be inadequate (Cory and Rahman 2009). In Detroit, thousands face water shutoffs due to an inability to pay their monthly bills (Lukacs 2014), and in the United Kingdom, almost 24 percent of households are "water poor," paying more than 3 percent of household monthly income for water and sanitation services (Bradshaw and Huby 2013). Water quality threatens human health and well-being for rural communities and the urban poor. Small rural water suppliers chronically violate federal statutes protecting safe drinking water (Balazs et al. 2011; Satija 2014), and Native American communities face increased risk of drinking water contamination in water systems (Mascarenhas 2007). Yet, as some have pointed out, the poor in developed countries "do not count among the world's 1.1 billion who lack access to safe drinking water or 2.4 billion who lack access to improved sanitation" (Wescoat et al. 2008, 802).

Technical challenges are regularly cited as the cause of domestic water service delivery problems in the Global North. Poor water-system design, lack of trained operators, and insufficient economies of scale for rural community water systems are cited as the causes leading to chronic boil water advisories (Patrick 2011a, 2011b). Geographic isolation, paired with poverty, is also posited as a reason for poor drinking water access (Wescoat, Headington, and Theobald 2008). In other places, dishonest land developers, minimum enforcement of plumbing codes, inadequate low-income housing stock, and water pricing schemes are

The Professional Geographer, 68(1) 2016, pages 66–81 © Copyright 2016 by American Association of Geographers.
Initial submission, June 2014; revised submission, August 2014; final acceptance, August 2014.
Published by Taylor & Francis Group, LLC.

cited as contributing factors to poor water service in low-income areas in the United States (Ward 1999; Olmstead 2003).

Although previous studies on drinking water access are meritorious, current explanations narrow the discussion to technical gaps or pricing problems that interrupt physical flows of water to consumers despite the growing scholarship in human–environment geography that examines water provision as more than infrastructure. Drinking water is part of a larger hydrosocial waterscape, defined as a system bound together by dynamic circuits of knowledge, measurements, devices, organizations, institutional practices, and governance regimes (Linton and Budds 2014). Social and political processes constitute and mediate these circuits that allocate water flows and hydrological services through communities and across regions to water users and beneficiaries. Thus, our starting point is to frame the problem of drinking water provision in the Global North in terms of relational patterns of water access, everyday water practices, and the experiential or subjective dimensions of the hydrosocial cycle that dynamically reconstitute the waterscape (Sultana 2011; Jepson and Lee 2014). The challenge is how to operationalize the relational approach in a manner that is analytically robust, while offering opportunities to translate results into public policy that can materially improve drinking water quality for the marginalized in the Global North.

This article contributes to recent work on domestic water provision among marginalized communities in the Global North. First, we build on previous studies to advance the multidimensional concept of water security as a promising metric to assess the everyday experiences of water (Jepson 2014). Water security, defined in terms of human development, is considered adequate, reliable, and affordable water for a healthy life (Lundqvist, Appasamy, and Nelliyat 2003; Wolf 2011; Cook and Bakker 2012). One can refine water security for human development into three dimensions: water access, quality, and water affect (Wutich and Ragsdale 2008; Jepson 2014). This framework allows for the assessment of how gaps in water reliability, quality, and affordability erode the functioning for basic human activities. Water security includes, but is not limited to, water access; other characteristics such as affordability, quality, and the subjective experiences of domestic water provision are equally important. This is different than the concept of water poverty, which primarily addresses water access as a function of scarcity in terms of infrastructural and environmental issues at larger scales. Second, we examine the question of water security at the household level. By documenting water security variability among households in similar low-income populations, we might reveal contributing factors to water insecurity that have been previously overlooked at other scales.

Nowhere else does the relationship between domestic water provision and social exclusion come into such stark relief than in communities called *colonias*. Colonias are impoverished and mostly unincorporated subdivisions populated by Mexican Americans located on urban fringes or in rural areas along the 2,000-mile U.S.–Mexico border. Although conditions have improved over the past decades (Durst and Ward 2013), colonias, home to more than 400,000 residents, are typically characterized by inadequate water and sanitation services, lack of electricity, and unpaved roads (Ward 1999; Donelson and Esparza 2010; McDonald and Grineski 2012; Office of the Attorney General 2012; Korc and Ford 2013). Recent work has examined the complex and dynamic social life of water prevalent in border colonias (Jepson and Lee 2014; Vandewalle and Jepson 2014). This article poses a further question: What household-level characteristics predict water insecurity within border colonias?

After placing the study in its regional context and describing the study's qualitative research and survey methods, we propose a novel measurement to assess household water insecurity and then employ two logistic regression models (binary and ordered) to identify household characteristics that are likely to result in household water insecurity. In the binary logistic regression model, the dependent variable is water insecurity. In the ordered logistic regression model, we use the natural order of dependent variables (water secure, marginally water secure, marginally water insecure, water insecure) where higher categories indicate increased household water insecurity. Our analysis, although preliminary, is significant because it is the first regression model using a measurement of water security at the household scale.

Our results yield some unexpected findings concerning the relevance of immigration status to household water insecurity. Notwithstanding some weaknesses in the study, it is clear that adequate, reliable, and affordable water for a healthy life is a "material emblem of citizenship" (Bakker 2010, 55); for colonias communities on the border, immigration status might influence household water insecurity more than previously expected. Broadly, these results underscore the need to examine the social and political determinants of household water insecurity in marginalized communities rather than ascribing water insecurity to technical gaps in water delivery systems.

Household Water Insecurity Along the U.S.–Mexico Border

The waterscape on the Texas–Mexico border is defined by complex hydrosocial interactions among institutions, organizations, and technologies that allocate the flow of water across the region and through infrastructure to different water users (Jepson 2012; Jepson and Brannstrom 2015). Rio Grande water eventually finds its way to poor households through circuits of irrigation-district canals, quasi-public community water networks, inadequate household connections, water vending machines, and garden hoses

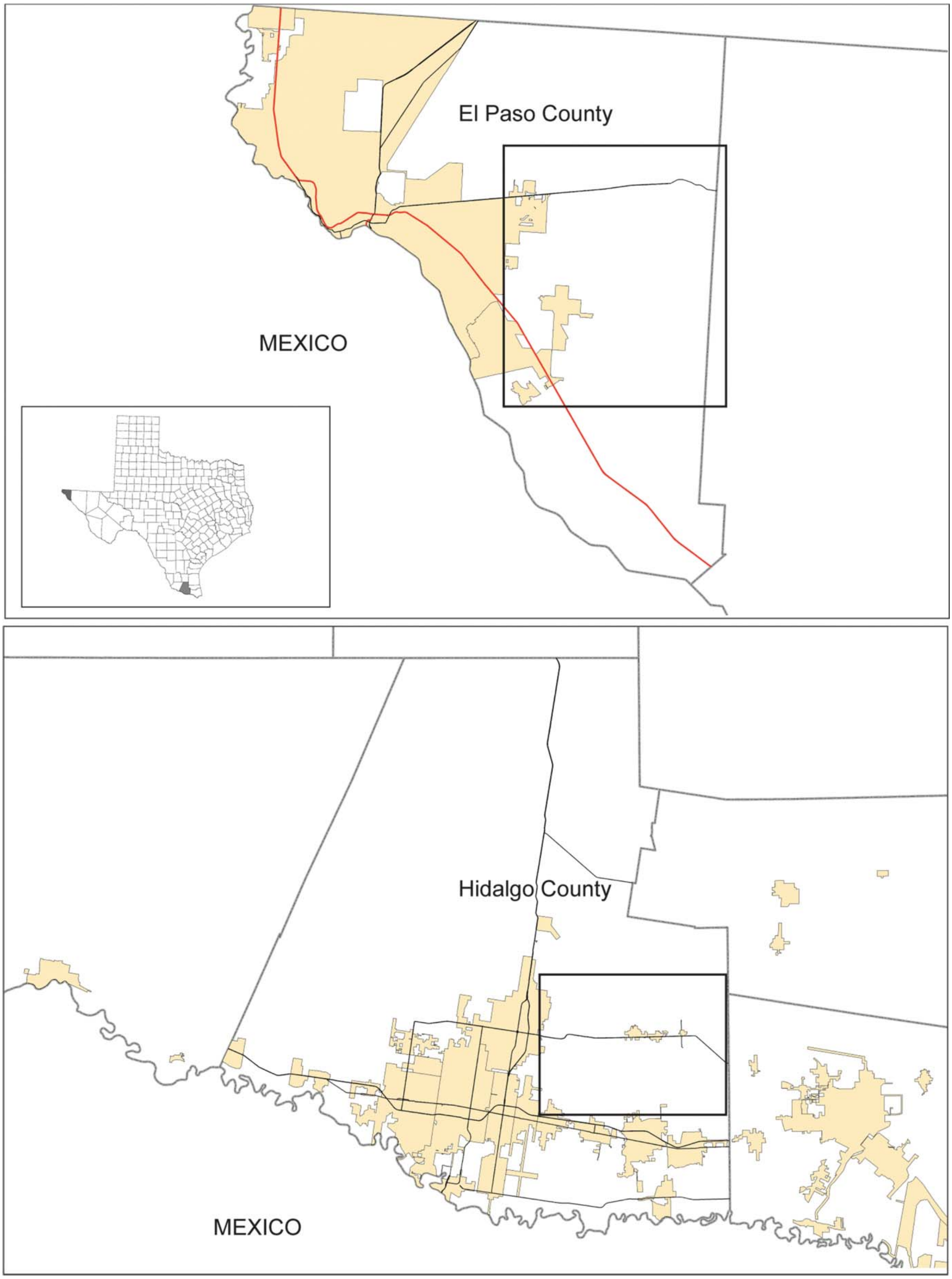

Figure 1 *Study sites: El Paso County and Hidalgo County. (Color figure available online.)*

to be stored in fifty-gallon barrels, buckets, or five-gallon plastic bottles. A fragmented regime of water governance institutions, water markets, housing codes, and private corporations direct the water flow to households in border colonias. The focus of this study is two of the poorest regions in the United States: (1) Hidalgo County in the Lower Rio Grande Valley, with the largest concentration of colonias (over 240,000 people), and (2) El Paso County in West Texas (Figure 1). The boxes indicated in Figures 1

Table 1 *Income, poverty, and plumbing data for selected census tracts in study sites*

	Hidalgo County	El Paso County
Average per capita income	$9,938	$15,257
% households with income below federal poverty level	44.3	24.4
% households that lack complete plumbing	7.07	5.6

Note: Data from U.S. Census Bureau (2010).

and 2 are sections of each county selected for consistency and to minimize exogenous factors. Demographic data compare study census tracts levels of poverty and households without complete plumbing[1] (Table 1, Figure 2).

Residents in border colonias have few reliable, affordable, and adequate options for drinking water. They face a "no-win" waterscape. Existing domestic water provision is available but expensive, highly variable, and unreliable, and water quality is demonstratively precarious. Residents face service interruptions due to lack of payment, unreliable water service, and concerns over tap water quality. Some households avoid existing water utilities altogether and use garden hoses to connect to a neighbor's water meter (Figure 3).

Several households not connected to community water service might live in areas not served by a water supply corporation. For example, 4,500 residents living in sixty El Paso colonias are not connected to community water systems. In other cases, households cannot afford the water connection costs, or they cannot afford the household improvements necessary to comply with building codes, a prerequisite for waterline hookups. Instead, residents rely on water delivery trucks to fill large 1,500- to 2,500-gallon plastic storage tanks. Trucked water, despite claims to the contrary, is not considered potable, and many residents experience skin rashes due to contamination (Graham and VanDerslice 2007; McDonald and Grineski 2012; Figure 4). Finally, most households, whether connected to a community water system or not, depend on unreliable water vending machines because of generalized tap water quality concerns (Chaidez et al. 1999; Schillinger and Knorr 2004; Figure 5).

Data and Methods

Household Surveys

Qualitative research was conducted in Hidalgo County during nine visits between January 2009 and August 2011. The first author led a research team, including a local community health worker (*promotora*), as they conducted forty-one semistructured interviews and two focus groups. The first author used qualitative information to develop a household water security survey, which was then completed for seventy-one households in Hidalgo County (sixty-eight households used in study) in July 2012. The second author conducted sixty-six household surveys in El Paso County and Doña Ana County (New Mexico) in July 2013. We used the State of Texas colonia classification system to stratify our sample of households (Parcher and Humberson 2009). We selected households in eleven different colonias in eastern Hidalgo County and fourteen different colonias in eastern El Paso, with households representing each colonia classification: red, yellow, green, and unclassified (Table 2). We also surveyed colonias not classified in the Texas database. We removed six household surveys from adjacent counties in New Mexico when we ran the logistic regression models to limit our analysis to Texas counties. The surveys were conducted in Spanish or English with the available head of household. The survey, which took between thirty and forty-five minutes, was divided into four parts: (1) household demographics (age, occupation, health care access, country of origin, etc., for each household member), (2) water usages and practices, (3) series of yes–no questions related to the three water dimensions, and (4) income and wealth. Descriptive statistics of households are provided in Table 3.

Data Analysis

We analyzed household survey data using three techniques. First, we used an experiential scalogram technique (Guttman 1945) to draw inferences about a latent variable (water insecurity) in the observed data (Guttman 1945; Guest 2000). In this study we created three scalograms for each dimension of water security. Guttman scalograms provide a measurement of cumulative or progressive objective, subjective, and biocultural experiences; it has been particularly useful when related to domestic water access and food security (Wutich and Ragsdale 2008; Hadley and Wutich 2009; Stevenson et al. 2012). For Hidalgo County, we used household scales and classifications from previously published data (Jepson 2014), and we followed the same procedure to create the water security scales and classification for households in El Paso.

Survey item responses were entered 0 or 1 into a respondent-by-item matrix for each dimension of water security, with each row representing a household respondent and each column representing an indicator for each dimension of water security (water access, water quality acceptability, water distress). Guttman scalograms order item responses such that the individual who responded more positively will rank higher than an individual who responded negatively, and the positions of the item responses and individuals are given numerical values. Three conventional measures of reliability for each scale were calculated: coefficient of reproducibility (CR), coefficient of

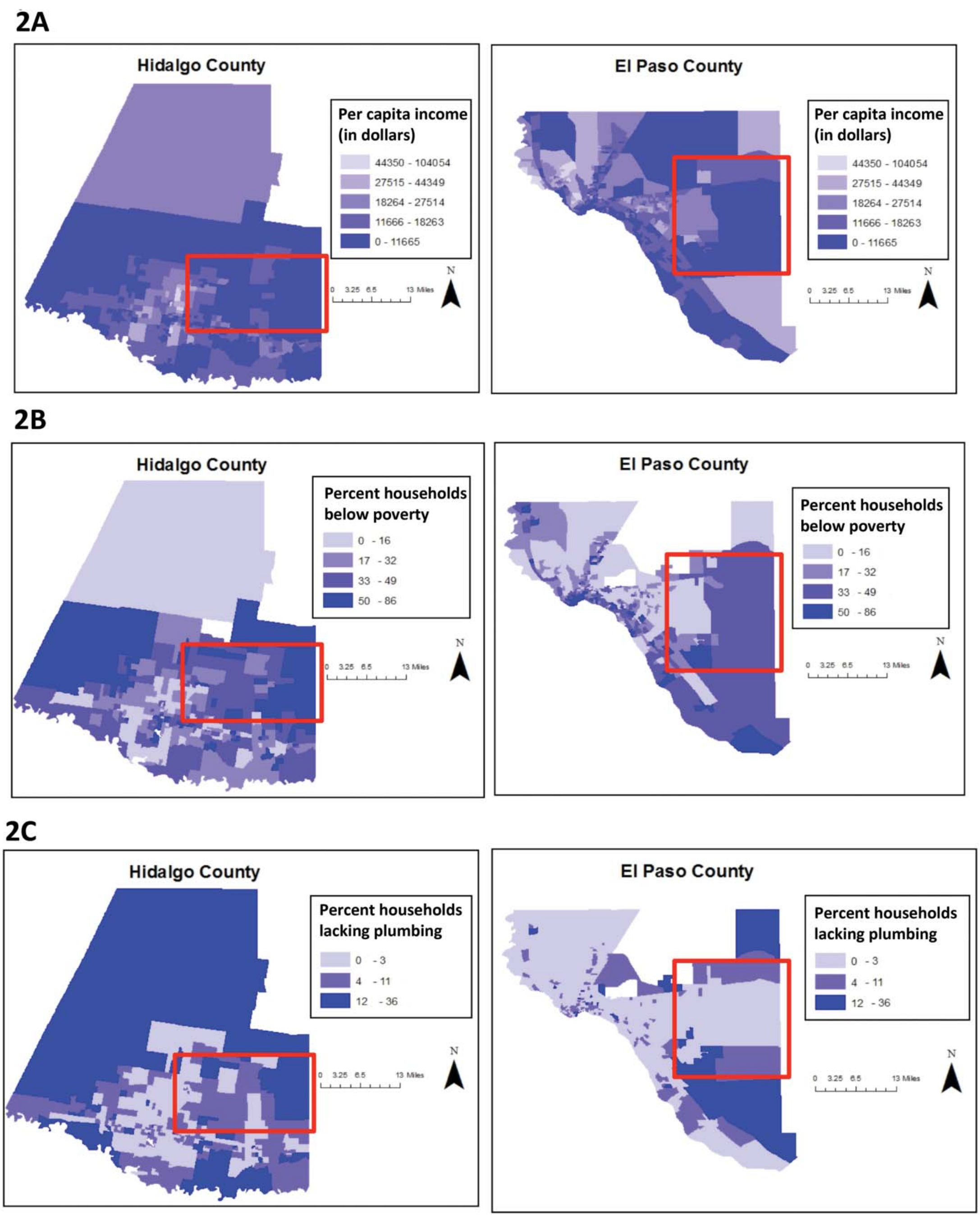

Figure 2 *Census tract data for study counties and tracts (per capita income, poverty, complete plumbing). (Color figure available online.)*

scalability (CS), and minimal marginal reproducibility (MMR). The CR should be greater than 0.90, CS more than 0.60, and MMR less than 0.90 (Guest 2000; Peregrine, Ember, and Ember 2004; Table 4).[2]

The experience-based indicators that correspond with survey item responses used in scale development are described in the idealized Guttman scales (Table 5). For example, households that experienced the lowest water access reported the presence of all the indicators, but households with the most water access experienced none or the first listed indicator. In addition, Table 5 reports the number of households that positively responded to the presence of each indicator. For example, water was not affordable in 84 percent of Hidalgo County households and in 91 percent of El Paso households. Similarly,

Figure 3 *Two homes that might share a water connection through an outside faucet; no other water or sanitation connection was observed for these dwellings. (Color figure available online.)*

Figure 4 *Household water storage tank. (Color figure available online.)*

Figure 5 *Water vending machines. (Color figure available online.)*

Table 5 reports other positive responses or presence for each dimension of water security (access, quality, distress).

Second, we clustered households into four groups of water security using the three scale scores by applying the centroid method and squared Euclidean distance measurement to create a dendrogram in S+ software (TIBCO 2010). The four household water security groups or classes are (1) water secure, (2) marginally water secure, (3) marginally water insecure, and (4) water insecure. We used R software to test the hypothesis of no difference between two or more groups among the four groups using the nonparametric multiresponse permutation procedure (MRPP; Biondini, Mielke, and Berry 1988; Mielke and Berry 2001; Figure 6). We could reject the null hypothesis because the A statistics (measure of effect size) were acceptable and p values were significant for both counties.

Third, we used household survey data and household water security classifications to run two logistic regressions to determine which household characteristics will more likely result in water insecurity. We compared households that fell between 50 and 99 percent below the federal poverty level (FPL) and those households 49 percent or below with those above the FPL as our dummy variable. We also

Table 2 *Classification criteria for colonias*

Health risk	Classification	Description
High	Red	One of the following is lacking: • Adequate wastewater disposal • Potable water supply • Platted
Medium	Yellow	Colonias platted with a potable water supply and adequate wastewater disposal system but are lacking in one of the following: • Trash collection • Paved roads • Passable roads during weather conditions • No flooding during precipitation event
Low	Green	All of the following are present: • Platted • Potable water supply • Adequate wastewater disposal • Trash collection • Paved roads • Passable roads during weather conditions • No flooding during precipitation event

Note: Adapted from Parcher and Humberson (2009, 136).

Table 3 Household characteristics

		Household demographics (average)				Household monthly income		Water	
Location	N	Adult	Child	Over 65	Household members	Total $	% of federal poverty level	Expense	Affordability (%)
Hidalgo County									
Green	8	3.00	3.12	0.13	6.25	1,168	40.53	$77	9.1
Yellow	19	2.36	1.84	0.37	4.58	1,895	97.50[a]	$59	5.8[a]
Red	15	2.06	0.80	0.60	3.46	1,381	70.00	$55	7.0
Unknown	29	2.48	2.58	0.03	5.13	1,307	48.80	$67	8.3
Total	71	172	147	18	338				
El Paso County									
Green	6	2.33	1.33	0.00	3.67	1,033	49.14	$65	10.9
Yellow	18	1.72	1.28	0.17	3.17	1,167	86.37	$67	16.0
Red	19	1.89	1.16	0.37	3.42	1,260	85.36	$122	15.7
Unknown	17	2.00	1.59	0.35	3.94	1,180	60.43	$69	6.8
Total	60	115	80	16	211				

[a]Three respondents did not indicate income.

Table 4 Guttman measurements of reliability

	CR	CS	MMR
Hidalgo County			
Water access	0.92	0.86	0.43
Water quality acceptability	0.93	0.83	0.54
Water distress	0.91	0.86	0.36
El Paso County			
Water access	0.94	0.87	0.50
Water quality acceptability	0.95	0.90	0.50
Water distress	0.91	0.83	0.49

Note: CR = coefficient of reproducibility; CS = coefficient of scalability; MMR = minimal marginal reproducibility.

classified households in terms of age composition (minors and adults; minors, adults, and elderly [65 and over]; only adults; only elderly). We included dwelling information, such as type (manufactured home or house) and years in residence. We also wanted to test whether the State of Texas colonia classification on "health risk" predicted household water insecurity.

Field research and emerging literature on immigration status and immigrant families' quotidian negotiation to access utilities informed our decision to include immigration status as a possible predictor for household water security (Stevens, West-Wright, and Ysai

Table 5 Idealized scale indicators and positive responses (% of households), Hidalgo and El Paso Counties

Hidalgo	% households	El Paso	% households
Water access scale		Water access scale	
Water is not affordable	84	Water is not affordable	91
Conserves water/reallocates resources to pay for water	71	Conserves water/reallocates resources to pay for water	74
Lacked money to pay for water/missed bill	51	Physical burden to clear tank/*garrafones*	56
Problems with water pressure	41	Lacked money to pay for water/missed bill	35
Problems buying water/paying bills (transport, physical burden)	37	Physical burden to buy water at vending point/haul water	33
Water cut or interrupted	18	Problems buying water/paying bills	30
Shares water meter or given water	7	Shares water meter or given water	27
Water quality acceptability		Water quality acceptability	
More than 50% drinking water from bottles or water vending machine	87	More than 50% drinking water from bottles or water vending machine	76
Does not disinfect container (*garrafon*) after each use	78	Tap or trucked water has unpalatable taste or smell (chlorine, soil, metallic, salty)	71
Tap water has unpalatable taste or smell (chlorine, soil, metallic)	75	Tap or trucked water visually unclean (dirty, cloudy, floaters)	42
Water containers (*garrafones*) older than 6 months	65	Does not disinfect container (*garrafon*/tank) after each use	36
Tap water visually unclean (dirty, cloudy, floaters)	26	Water containers (*garrafones*) older than 6 months	24
Believes tap water made someone in household ill	21		
Water distress scale		Water distress scale	
Worried	66	Dissatisfied	58
Disgusted	44	Troubled or uneasy	53
Troubled or uneasy	40	Worried	47
Dissatisfied	29	Disgusted	47
Frightened or scared	28	Argued about water/negative comments to others	45
Argued about water/negative comments to others	18	Fear	42

2010; Kaushal, Waldfogel, and Wight 2013; White et al. 2014).[3] Considerable federal immigration enforcement through the Secure Communities program and the daily operations of the U.S. Border Patrol, with a federal mandate to search for unauthorized migrants within 100 miles of the border, make everyday life a constant and complex negotiation for immigrants (Menjivar 2011; Varsanyi et al. 2012). In this context, migrants make strategic efforts to negotiate everyday life, dangers, and insecurities (Garcia 2014). Furthermore, the existing immigration regime creates a chronic sense of insecurity and psychosocial distress and anxiety, particularly for mixed-status households who fear separation through deportation (Brabeck, Brinton Lykes, and Hershberg 2011). Taken together, immigration status merited inclusion in the model as the legal precarity might create a spillover effect in terms of household water (in)security.

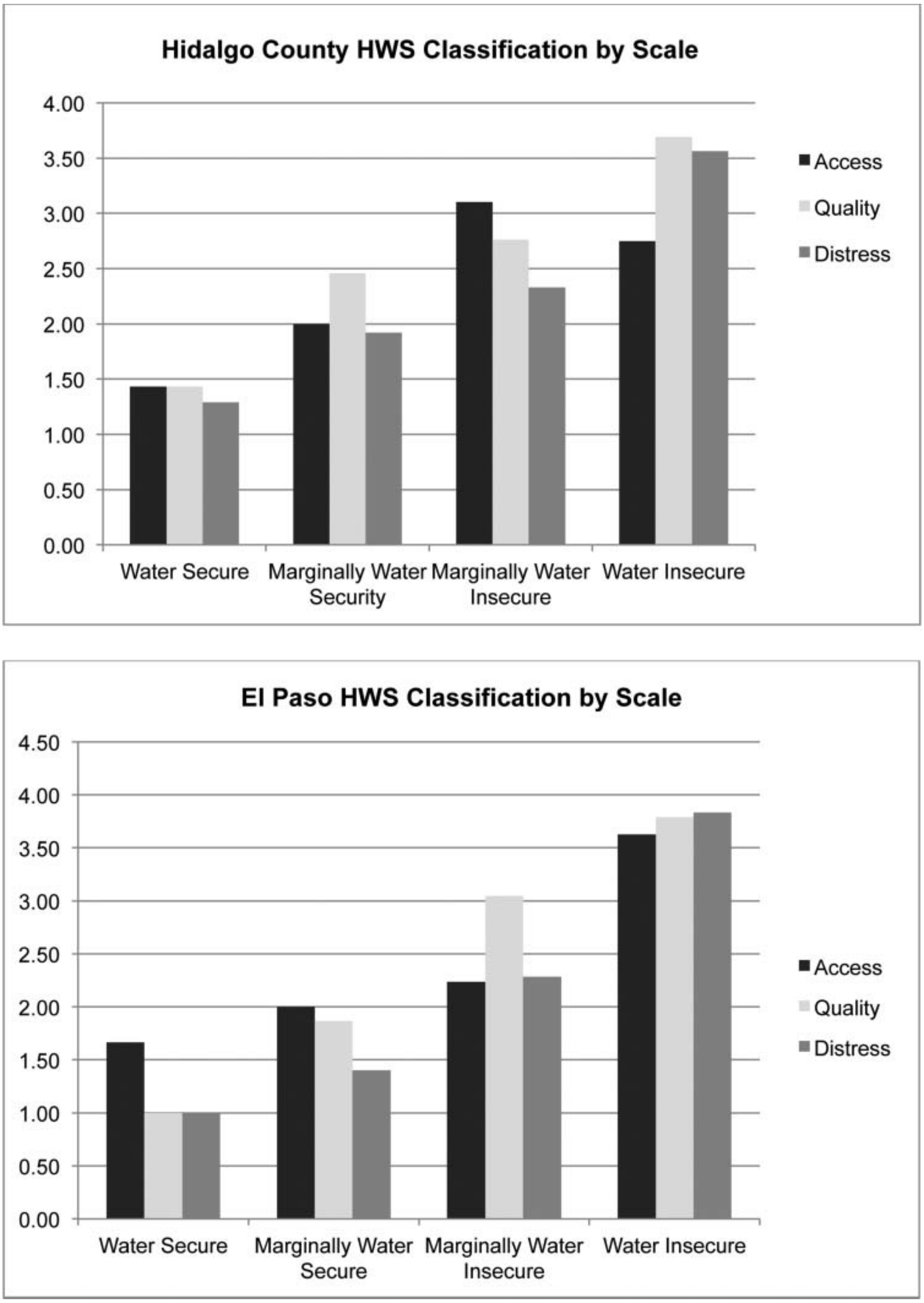

Figure 6 *Household water security (HWS) classification by scale (mean scale score).*

We did not explicitly ask immigration status of household members; however, a combination of responses from several survey questions—place of birth, sources of income (including public benefit), time of residency, insurance coverage—allowed us to deduce and estimate documented or undocumented status. We noted households receiving Temporary Assistance for Needy Families, Social Security (including SSI Disability), and Supplementary Nutrition Program (SNAP, or food stamps) because monthly benefits require documented status. We also noted whether the distribution of these benefits varied between and within each household. For example, we surveyed households in which all of the children under the age of eighteen would be eligible for Children's Health Insurance Program or Medicaid but not all of them receive the benefits. Similarly, a household might receive SNAP benefits for some children but not as a household or at the maximum eligible under current state provision. We recognize that SNAP eligibility for adults is variable, but since July 2002 children under eighteen who are legal residents are eligible for benefits (Wight et al. 2014). This intrahousehold variability, paired with other data on birthplace, strongly suggests whether the household is a mixed-status or all-undocumented household. If no proxy evidence for residency status was obtained, we classified the household as all documented.

We conducted two types of statistical analyses using R software (R Core Team 2014). First, we employed a binary logistic regression, which estimates coefficients and reports an odds ratio for explanatory variables on the outcome variable. A binary logistic regression is an appropriate statistical model because the outcome variable is binary and categorical (water secure–water insecure). Odds ratios higher than 1.0 for the explanatory variable indicate a greater likelihood that the outcome (water insecurity) will occur. An odds ratio less than 1.0 indicates a negative effect or a lower likelihood that the outcome will occur. Second, we performed an ordered logistic regression (OLR) model, which is similar to the binary logistic regression model but for multiple outcome variables that are categorical (water secure, marginally water secure, marginally water insecure, and water insecure). OLR models the relation between the previous independent variables and the four household water security classifications while controlling for the covariates. Regression results are reported as adjusted odds ratios (ORs) and 95 percent confidence intervals (CIs) for moving to higher water insecurity categories versus remaining in the same category. That is, OLR models cumulative probability, or the factors that increase or decrease the likelihood of being in a higher category of household water insecurity. For the OLR, an odds ratio higher than 1.0 for the explanatory variable indicates a greater likelihood of being in higher water insecurity categories versus remaining in the same category. Conversely, an odds ratio less than 1.0 indicates a negative effect or a lower likelihood of being in higher water insecurity categories versus remaining in the same category.

Results

Comparing Scalograms and Household Water Security

Guttman scalograms for each of the three dimensions of water security offer a means to compare regional differences among colonias surveyed in El Paso and

Table 6 *Water security scales and household water security classifications*

	Hidalgo County[a]		El Paso County[b]	
	No. households	**% households**	**No. households**	**% households**
Water access				
Adequate water access	4	6	5	8
Marginal water access	35	51	31	52
Low water access	23	33	7	12
Very low water access	6	9	17	28
Water quality acceptability				
Acceptable water quality	6	9	13	22
Marginal acceptability	23	34	8	13
Low acceptability	22	32	18	30
Very low acceptability	17	25	21	35
Water distress				
Low water distress	13	19	22	37
Marginal water distress	27	40	10	17
High water distress	18	26	8	13
Very high water distress	10	15	20	33
Household water security				
Water secure	7	10	6	10
Marginally water secure	24	35	15	25
Water insecure	21	31	19	32
Highly water insecure	16	24	20	33

[a] $N = 68$.
[b] $N = 60$.

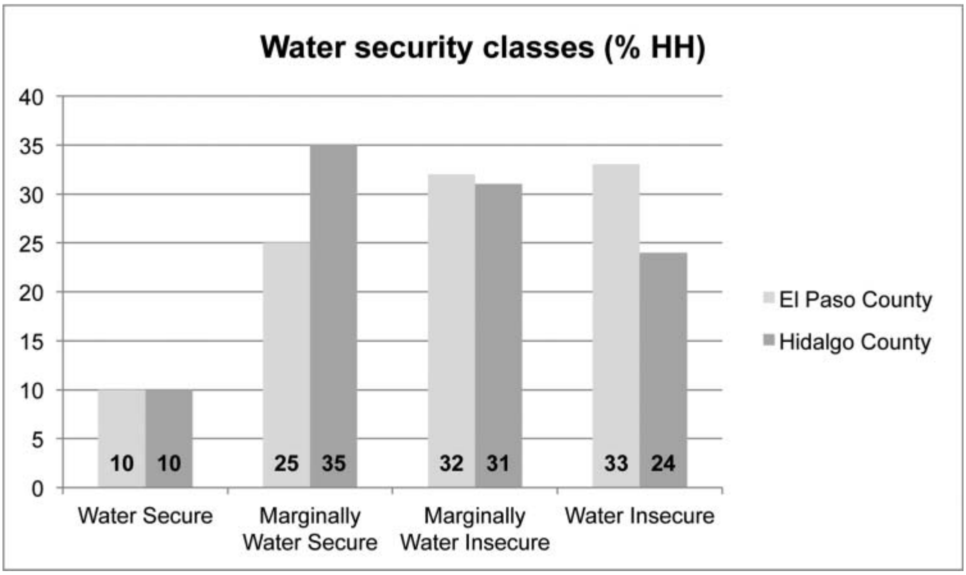

Figure 7 *Water security classes for surveyed households in El Paso and Hidalgo counties.*

Hidalgo Counties (Table 6). The analysis clustered scale scores so that each household was classified in terms of household water security: (1) water secure, (2) marginally water secure, (3) marginally water insecure, or (4) water insecure (Table 6, Figure 7). In general, more households are water secure in Hidalgo County than in El Paso County. Although the analysis indicates that 10 percent of the colonia households in both regions are water secure, more than a third of the surveyed households in Hidalgo County are marginally water secure (35%), whereas only a quarter of the households in El Paso County are marginally water secure (25%). Similarly, the percentage of households classified as marginally water insecure is almost equal in each county (32 percent, El Paso; 31 percent, Hidalgo), but one third of the surveyed households in El Paso County are water insecure (33 percent), whereas a quarter of the households in Hidalgo County (24 percent) are classified as water insecure.

Binary Logistic Regression

Table 7 summarizes the outcome and explanatory variables used in the regression models. Table 8 presents the results from the logistic regression model for household water insecurity. Overall the model is reasonably strong as indicated by the likelihood ratio chi-square value, which is statistically significant ($p < 0.05$).

Household immigration status is an important factor to consider in household water insecurity. The analysis indicates that "mixed status" households were 4.2 times more likely to be water insecure than households with members who were all documented (legal residents or U.S. citizens). Households in which all members are unauthorized residents increase the likelihood (1.2 times) of water insecurity, but the results were insignificant. Birthplace, which is different than legal status, also significantly affected household water insecurity. Households with both U.S.- and foreign-born members are 20 percent less likely to be water insecure than households in which all members were born in the United States.

Other socioeconomic variables such as size of household increase the likelihood of household water insecurity, but the results are all insignificant. Poverty level runs in the direction anticipated. Households between 50 percent and 99 percent of the FPL are almost twice as likely to be water insecure than those above the FPL, and the households below 49 percent of the FPL are 1.5 times more likely to be water insecure than those above the FPL. Households with members that include children, adults, and elderly are 6.3 times more likely to be water insecure than households with only adults or only elderly. Although the p value is slightly more than 0.01 (p value = 0.127), it approaches significance and therefore is an important finding.

The model also considers residential factors on household water insecurity. Living in a manufactured home (recreational vehicle [RV] or mobile home) was not an important predictor of household water insecurity. The model confirms expectations, however, that households in "red" colonias were more likely (4.7 times) to be water insecure as compared to households in the "green" classified colonia. Although living in a colonia classified "red" significantly increased the likelihood of water insecurity, the other colonia classifications are poor predictors of household water insecurity. Surprisingly, the model indicates that

Table 7 *Definitions and descriptive statistics for outcome and explanatory variables*

	M	*SD*
Outcome variables		
Household water security (binary)	0.60	0.50
Water secure = 0		
Water insecure = 1		
Household water security (ordered)	2.80	0.98
Water secure = 1		
Marginally water secure = 2		
Marginally water insecure = 3		
Water insecure = 4		
Explanatory variables		
Socioeconomic variables		
Size of household	3.97	2.25
Poverty level (1 = above 100%, 2 = 50–99%, 3 = 49% and below)	2.32	0.76
Receiving SNAP/TANF/SSI (yes = 1, no = 0)	0.59	0.50
Children under 18	1.77	1.77
Persons over 65	0.29	0.58
Residency status (1 = all documented, 2 = mixed, 3 = all undocumented)	1.71	0.71
Birthplace (1 = all U.S., 2 = mixed, 3 = all non-U.S.)	2.16	0.61
Housing composition (1 = child and adult; 2 = child, adult, and elderly; 3 = only adult; 4 = only elderly)	1.87	1.03
Dwelling		
Type of dwelling (1 = RV/mobile home, 0 = house)	0.46	0.50
Years in current residence	9.99	7.93
Location variables		
Colonia type (green = 1, yellow = 2, red = 3, unknown = 4)	2.92	1.02

Note: $N = 130$. SNAP = Supplementary Nutrition Program; TANF = Temporary Assistance for Needy Families; SSI = Social Security Insurance; RV = recreational vehicle.

Table 8 *Results of binary logistic regression and ordered logistic regression*

	Binary logistic regression			Ordered logistic regression		
	Odds ratio	***Z* score**	***p* value**	**Odds ratio**	***t* value**	***p* value**
Socioeconomic variables						
Size of household	1.232	1.508	0.131	1.050	0.549	0.582
Poverty level						
Above 100%	—	—	—	—	—	—
50–99%	1.990	0.987	0.323	1.997	1.142	0.253
Below 49%	1.582	0.639	0.533	2.690	1.545	0.122
Receive SNAP/TANF/SSI	0.878	−0.248	0.804	0.891	-0.263	0.792
Residency status						
All documented	—	—	—	—	—	—
Mixed-status household	4.227	2.499	0.012*	2.471	2.049	0.040**
All undocumented	1.261	0.263	0.797	3.035	1.546	0.121
Birthplace						
All U.S.	—	—	—	—	—	—
Mixed-birthplace household	0.200	−2.027	0.042*	0.386	−1.498	0.134
All non-U.S.	1.282	0.263	0.792	0.484	−0.944	0.344
Household composition						
Child/adult	—	—	—	—	—	—
Child/adult/elderly	6.330	1.523	0.127	2.829	1.392	0.163
Only adults/elderly	0.914	−0.140	0.888	1.490	0.734	0.462
Only elderly	0.394	−0.834	0.404	0.595	−0.523	0.600
Dwelling						
Home type (0 = house, 1 = RV/mobile home)	0.727	−0.726	0.468	0.919	−0.237	0.812
Time in residence (years)	1.019	0.618	0.536	1.016	0.665	0.505
Location variables						
Colonia type						
Green	—	—	—	—	—	—
Yellow	0.819	−0.257	0.7972	1.405	0.559	0.575
Red	4.698	1.788	0.0737+	7.860	3.020	0.002**
Unknown	1.201	0.234	0.8147	1.690	0.848	0.396

Note: Likelihood ratio $\chi^2(16) = 28.21$*. Model *p* value = 0.0297. SNAP = Supplementary Nutrition Program; TANF = Temporary Assistance for Needy Families; SSI = Social Security Insurance; RV = recreational vehicle.
+$p < 0.1$.
*$p < 0.05$.
**$p < 0.01$.

households in "yellow" colonias are 81 percent less likely to be water insecure than those in "green" colonias, although the result is not significant.[4] This contrasts with colonias that are unclassified, where households in these neighborhoods are 1.2 times more likely to be water insecure than those in the "green" colonias.

Ordered Logistic Regression

The OLR model reports many similar relationships between the independent and dependent variable (household water insecurity) as the first binary logistic regression but with some notable differences (Table 8). Households with residents of mixed documentation are 2.4 times more likely to be classified in a higher category of household water insecurity than households with all members documented. Although significant, this is less than predicted in the binary logistic regression model. The OLR model also indicates that households with all undocumented residents are three times more likely to be classified in higher levels of household water insecurity. Although this finding was not statistically significant, the *p* value was approaching significance and therefore we consider an important relationship between all undocumented households and water insecurity. Households with mixed U.S.- and foreign-born residents are 38 percent less likely to be classified in higher levels of water insecurity than households with all U.S.-born residents, which is a higher likelihood than in the binary logistic regression. Households with all foreign-born members are also less likely to be in a higher water insecurity category than all U.S.-born households. Although insignificant, it is notable that this is a shift in direction from the binary logistic regression model.

Similar to the binary regression model, other socioeconomic variables, such as size of household, increases the likelihood of household water insecurity, but the results are insignificant. In addition, relative poverty level runs in the direction anticipated, but results from our analysis are all insignificant. Households between 50 and 99 percent of the FPL are about twice as likely to be in a higher household water insecurity category than those above the FPL, a very similar result from the binary regression. Households below 49 percent of the FPL are 2.6 times more likely to be in a higher water insecure category than those above the FPL, which is notably different than the result from the binary regression. Similarly, households that receive public benefit run in the negative direction to household water insecurity but, as with the binary logistic regression model, this is statistically insignificant. As in the binary logistic regression model, households with members that include children, adults, and elderly are more likely to be water insecure (2.8 times) than households with only adults or only elderly. Although the *p* value is more than 0.01, it approaches significance with a *p* value of 0.163 and therefore is an important finding. The OLR model confirms that dwelling type and time in residence are poor predictors of household water insecurity.

The OLR model presents a clearer relationship between households living in "red" colonias and higher levels of household water insecurity than those in the binary regression. These households are 7.8 times more likely to be in a higher category of household water insecurity and with a stronger significance value. In the binary regression model, households in "yellow" colonias are less likely to be water insecure than households in "green" colonias, but the OLR model changes sthe direction of this relationship. There is an increased chance that a household in the "yellow" category will be observed in a higher category of household water insecurity but, again, the *p* value value indicates that this is not significant.

Discussion

Our research suggests that households living in border colonias—communities that are both connected to community water service and not connected to community water service—face significant levels of household water insecurity. Water insecurity varied, however, within similar subdivisions; thus, our work challenges the notion that colonias households form a homogenous group in terms of living conditions and access to resources. Our analysis attempted to determine what household-level characteristics would predict water insecurity in colonias households. The binary logistic regression modeled significant predictors for presence of household water insecurity; the OLR modeled the odds for a household moving to higher water insecurity categories versus remaining in the same category. Overall, household water insecurity is difficult to predict with statistical significance, but there were some unexpected results in our findings, particularly if we examine our preliminary findings in comparison with recent scholarship on experience of insecurity of everyday life on the U.S.–Mexico border.

First, we would have expected relative poverty to increase the likelihood of water insecurity, but our results indicate that the degree to which a household lives in poverty might not strongly influence water insecurity among this population. Although the reasons need to be investigated further, one can deduce that water is not affordable for most of the households because most are impoverished, and a majority of the surveyed households experience problems buying water or engage in practices to economize water use. Therefore, differences in terms of household water insecurity might reflect the experiences related to the other dimensions of water insecurity (quality and distress) and not to different levels of affordability or access.

Second, we would also expect that living in a mobile home would increase the likelihood of water insecurity because those units can be more easily located on land that does not necessarily follow water and sanitation codes. Moreover, colonia residents more frequently rely on the secondary market to buy aging mobile homes and RVs (Durst 2014); therefore, the internal infrastructure could be significantly depreciated, degrading water quality through the connection between the housing and the water supply. In addition, the literature would suggest that an increase in residence time might decrease the likelihood of water insecurity because of housing consolidation and dwelling improvements made over the life course (Durst and Ward 2013). Yet, our analysis indicates that factors related to the dwelling (e.g., dwelling types [mobile or RV vs. house] and time in residence [years]) do not increase the likelihood of household water insecurity to any significant degree.

Although we were not surprised that households in "red" colonias have a higher likelihood of being water insecure than households in "green" colonias, the result that other state-mandated colonias classifications were poor predictors of household water insecurity was unexpected. In many cases, especially in the El Paso "red" colonias, lack of either water or sanitation services set the stage for household water insecurity, whereas in Hidalgo County, households in "red" colonias lacked mainly sanitation. Moreover, although classification was a predictor, we documented various household levels of water insecurity in "red" colonias. Therefore, we can only conclude that the colonia classification system, although perhaps helpful in identifying the worst-case scenarios, is an inadequate proxy to assess the larger and more diverse experiences of household-scale water insecurity.

Finally, our analysis revealed a major unexpected predictor of household water insecurity—immigration status of household members—with mixed-status households as the most significant predictor of household water insecurity. Our findings, paired with existing research on mixed-status families, suggest that the quotidian behaviors and choices in response to precarious immigration status might "spill over" into other insecurities, including household water insecurity. Negotiating the immigration regime is defined by avoiding exposure to authorities. This can be achieved in terms of location of residences, and many colonias provide this protection as they are within the sparsely patrolled rural and periurban areas. Connection to public services might also be a perceived vulnerability and exposure point. Another form of "protection," confirmed anecdotally in field research, is the reliance or dependency on private water delivery—either trucked or vending machines. This allows individuals to manage chronic problems of water access and quality without directly addressing problems with the water supply corporations or municipal services. The impact could include increased costs of water, dependency on unregulated water sources, and increased water distress. Exploring these specific interactions is beyond the scope of this study, but we believe that future research should explore how immigration status might influence interactions with local water governance regimes as a significant factor in water insecurity.

Several important limitations should be considered when reviewing the results of this study and could inform future research. Although the study included an adequate number of households, a larger sample size might improve the robustness. Second, housing tenure—either rental, ownership (title), or contract-for-deed (final or interim)—would be another important variable to include in future surveys. Our current survey did not delineate the specific status of housing tenure, so we could not include this variable in our current model. As time in residence, the variable we used, might autocorrelate with housing tenure, future research would have to determine the best independent variable. Third, our analysis provided preliminary means to assess gaps in water reliability, quality, and affordability, but we recognize the need to refine the scalogram and classification analysis. For example, household water security classifications were generated based on experiential scales reflective of each place studied yet were aggregated in the regression analyses. That said, our study is in line with the experience-based scales, as these communities are similar in terms of culture and socioeconomic demographics.

Conclusion

Our study advanced current research on domestic water provision among marginalized communities in the Global North by applying methods to quantify household water insecurity. The empirical focus of this study was low-income, periurban and rural communities in two impoverished regions on the Texas–Mexico border: the Lower Rio Grande Valley and west Texas. The novel scale and classification system offered a systematic means to assess the three dimensions of household water security in a common measurement for households for two study areas. The results reveal notable regional differences. Households in both regions have an equal percentage classified as water secure, but there is a higher percentage of households surveyed in El Paso classified as marginally water insecure or water insecure. We also used household water security classifications developed from household survey data to run two statistical analyses: binary logistic regression and OLR. We determined that demographics, poverty, and housing infrastructure are relatively weak and statistically insignificant predictors of household water insecurity, whereas immigration status significantly increased the likelihood of household water insecurity. Our study suggests that future research should investigate why immigration status might be a predictor of water insecurity, repeat the logistic regression analysis with a larger sample size, and broaden the geographical distribution of study areas to advance our knowledge of the unevenness of household water insecurity. These research directions will enable further tests of the household water security measurement as a robust, reliable indicator, similar to the food security measurements, in the Global North. ■

Acknowledgments

We would like to thank Laura Treviño, research participants, community center volunteers, and promotoras for their help and support during the research process. We also want to thank David Cairns, Christian Brannstrom, Heather Lee, Vicenta Placensia, Nancy Plankey-Videla, and Adam Naito.

Funding

The research on which this article is based was funded by a grant (BSC-0924232) from the National Science Foundation (United States). The usual disclaimers apply.

Notes

[1] The U.S. Census Bureau defines complete plumbing as hot and cold running water, a flush toilet, and a bathtub or shower. All three facilities must be located inside the dwelling. Housing units are classified as lacking complete plumbing when any of the three facilities is not present.

[2] Fewer than nine indicators might produce a high coefficient of reproducibility by chance, but for both data sets the other measurements of acceptability far exceed guidelines.

[3] Over 4.5 million U.S.-born children have parents who are undocumented and 1 million children under 18 are undocumented (Passel and Cohn 2011). This supports the findings that 76 percent of children in Mexican immigrant families lived in "mixed status" households between 2001 and 2011 (Kaushal et al. 2013, 205).

[4] This result might be a result from a minimum *N* and household selection process.

Literature Cited

American Communities Survey. 2012. United States Census Bureau: American Communities Survey. http://www.census.gov/acs/www/ (last accessed 15 April 2012).

Bakker, K. 2010. *Privatizing water: Governance failure and the world's urban water crisis.* Ithaca, NY: Cornell University Press.

Balazs, C., R. Morello-Frosch, A. E. Hubbard, and I. Ray. 2011. Social disparities in nitrate-contaminated drinking water in California's San Joaquin Valley. *Environmental Health Perspectives* 119 (9): 1272.

Biondini, M. E., P. W. Mielke, Jr., and K. J. Berry. 1988. Data-dependent permutation techniques for the analysis of ecological data. *Vegetatio* 75 (3): 161–68.

Brabeck, K., M. Brinton Lykes, and R. Hershberg. 2011. Framing immigration to and deportation from the United States: Guatemalan and Salvadoran families make meaning of their experiences. *Community, Work and Family* 14 (3): 275–96.

Bradshaw, J., and M. Huby. 2013. Water poverty in England and Wales. *Journal of Poverty and Social Justice* 21 (2): 137–48.

Chaidez, C., P. Rusin, J. Naranjo, and C. P. Gerba. 1999. Microbiological quality of water vending machines. *International Journal of Environmental Health Research* 9 (3): 197–206.

Cook, C., and K. Bakker. 2012. Water security: Debating an emerging paradigm. *Global Environmental Change* 22 (1): 94–102.

Cory, D. C., and T. Rahman. 2009. Environmental justice and enforcement of the safe drinking water act: The Arizona arsenic experience. *Ecological Economics* 68 (6): 1825–37.

Donelson, A. J., and A. X. Esparza. 2010. *The colonias reader: Economy, housing, and public health in US–Mexico border colonias.* Tuscon: University of Arizona.

Durst, N. J. 2014. Second-generation policy priorities for colonias and informal settlements in Texas. *Housing Policy Debate.* doi:10.1080/10511482.2013.879603

Durst, N., and P. Ward. 2013. Measuring self-help home improvements in Texas colonias: A ten year "snapshot" study. *Urban Studies* 51 (10): 2143–59.

Garcia, A. 2014. Hidden in plain sight: How unauthorized migrants strategically assimilate in restrictive localities in California. *Journal of Ethnic and Migration Studies* 40 (12): 1895–1914.

Graham, G., and J. VanDerslice. 2007. The effectiveness of large household water storage tanks for protecting the quality of drinking water. *Journal of Water and Health* 5 (3): 307–13.

Guest, G. 2000. Using Guttman scaling to rank wealth: Integrating quantitative and qualitative data. *Field Methods* 12 (4): 346–57.

Guttman, L. 1945. A basis for analyzing test–retest reliability. *Psychometrika* 10 (4): 255–82.

Hadley, C., and A. Wutich. 2009. Experience-based measures of food and water security: Bicultural approaches to grounds measures of insecurity. *Human Organization* 68 (4): 451–60.

Harper, K., T. Steger, and R. Filčák. 2009. Environmental justice and Roma communities in Central and Eastern Europe. *Environmental Policy and Governance* 19 (4): 251–68.

Jepson, W. 2012. Claiming space, claiming water: Contested legal geographies of water in South Texas. *Annals of the Association of American Geographers* 103 (3): 614–31.

———. 2014. Measuring "no-win" waterscapes: Experience-based scales and classification approaches to assess household water security in colonias on the US–Mexico border. *Geoforum* 51:107–20.

Jepson, W., and C. Brannstrom. 2015. Techno-nature and the scaling of water governance. In *Negotiating scale in water governance*, ed. E. Norman, C. Cook, and A. Cohen, 155–71. London: Ashgate.

Jepson, W., and H. Lee. 2014. "If no gasoline, no water": Privatizing drinking water quality in South Texas colonias. *Environment and Planning A* 46 (5): 1032–48.

Kaushal, N., J. Waldfogel, and V. Wight. 2013. Food insecurity and SNAP participation in Mexican immigrant families: The impact of the outreach initiative. *The B.E. Journal of Economic Analysis and Policy* 14 (1): 203–40.

Korc, M. E., and P. B. Ford. 2013. Application of the Water Poverty Index in border colonias of west Texas. *Water Policy* 15 (1): 79–97.

Laurent, É. 2011. Issues in environmental justice within the European Union. *Ecological Economics* 70 (11): 1846–53.

Linton, J., and J. Budds. 2014. The hydrosocial cycle: Defining and mobilizing a relational-dialectical approach to water. *Geoforum* 57:170–80.

Lukacs, M. 2014. Detroit's water war: A tap-shut off that could impact 300,000 people. *The Guardian* 25 June. http://www.theguardian.com/environment/true-north/2014/jun/25/detroits-water-war-a-tap-shut-off-that-could-impact-300000-people (last accessed 25 June 2014).

Lundqvist, J., P. Appasamy, and P. Nelliyat. 2003. Dimensions and approaches for third world city water security. *Philosophical Transactions of the Royal Society B: Biological Sciences* 358 (1440): 1985–96.

Mascarenhas, M. 2007. Where the waters divide: First Nations, tainted water and environmental justice in Canada. *Local Environment* 12 (6): 565–77.

McDonald, Y. J., and S. E. Grineski. 2012. Disparities in access to residential plumbing: A binational comparison of environmental injustice in El Paso and Ciudad Juárez. *Population and Environment* 34 (2): 194–216.

Menjivar, C. 2011. The power of the law: Central Americans' legality and everyday life in Pheonix, Arizona. *Latino Studies* 9:377–95.

Mielke, P. W., Jr., and K. J. Berry. 2001. *Permutation methods: A distance function approach*. Berlin: Springer Verlag.

Office of the Attorney General. 2012. Colonias Prevention Program. https://www.oag.state.tx.us/consumer/border/colonias.shtml (last accessed 15 April 2012).

Olmstead, S. 2003. What's price got to do with it: Water supply and poor communities. *Environment and Planning A* 45 (10): 21–34.

Parcher, J., and D. Humberson. 2009. Using GIS to assess priorities of infrastructure and health needs of colonias along the United States–Mexico border. *Journal of Latin American Geography* 8 (1): 129–48.

Passel, J. S., and S. W. D. Cohn. 2011. *Unauthorized immigrant population: National and state trends, 2010*. Washington, DC: Pew Hispanic Center.

Patrick, R. J. 2011a. Enhancing water security in Saskatchewan, Canada: An opportunity for a water soft path. *Water International* 36 (6): 748–63.

———. 2011b. Uneven access to safe drinking water for First Nations in Canada: Connecting health and place through source water protection. *Health & Place* 17 (1): 386–89.

Peregrine, P. N., C. R. Ember, and M. Ember. 2004. Universal patterns in cultural evolution: An empirical analysis using Guttman scaling. *American Anthropologist* 106 (1): 145–49.

R Core Team. 2014. *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing. http://www.R-project.org/ (last accessed 7 May 2014).

Satija, N. 2014. Drinking water systems draw federal concerns. *The Texas Tribune*. http://www.texastribune.org/2014/17/23/texas-lags-behind-addressing-drinking-water-proble/ (last accessed 29 July 2014).

Schillinger, J., and S. D. V. Knorr. 2004. Drinking-water quality and issues associated with water vending machines in the city of Los Angeles. *Journal of Environmental Health* 66 (6): 25–31.

Stevens, G., C. West-Wright, and K. Ysai. 2010. Health insurance and access to care for families with young children in California, 2001–2005: Differences by immigration status. *Journal of Immigrant Minority Health* 12:273–81.

Stevenson, E. G. J., L. E. Greene, K. C. Maes, A. Ambelu, Y. A. Tesfaye, R. Rheingans, and C. Hadley. 2012. Water insecurity in three dimensions: An anthropological perspective on water and women's psychosocial distress in Ethiopia. *Social Science & Medicine* 75 (2): 392–400.

Sultana, F. (2011). Suffering for water, suffering from water: Emotional geographies of resource access, control and conflict. *Geoforum* 42 (2): 163–72.

TIBCO. 2010. *TIBCO Spotfire S+ 8.2—Guide to packages*. Palo Alto, CA: TIBCO Software.

U.S. Census Bureau. 2010. American fact finder. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml (last accessed 24 February 2012).

Vandewalle, E., and W. Jepson. 2014. Mediating water governance: Point-of-use water filtration devices for low-income communities on the US–Mexico border. Unpublished manuscript, Texas A&M University, Department of Geography, College Station, TX.

Varsanyi, M., P. Lewis, M. Provine, and S. Decker. 2012. A multilayered jurisdictional patchwork: Immigration federalism in the United States. *Law and Policy* 34 (2): 138–58.

Ward, P. 1999. *Colonias and public policy in Texas and Mexico*. Austin: The University of Texas Press.

Wescoat, J. L., Jr., L. Headington, and R. Theobald, R. 2008. Water and poverty in the United States. *Geoforum* 38 (5): 801–14.

White, K., V. Yeager, N. Menachemi, and I. Scarinci. 2014. Impact of Alabama's immigration law on access to health care among Latina immigrants and children: Implications for national reform. *American Journal of Public Health* 104 (3): 397–405.

Wight, V., N. Kaushal, J. Waldfogel, and I. Garfinkel. 2014. Understanding the link between poverty and food insecurity among children: Does the definition of poverty matter? *Journal of Children and Poverty* 20 (1): 1–20.

Wolf, A. T. 2011. Water and human security. *Journal of Contemporary Water Research and Education* 118 (1): 5.

Wutich, A., and K. Ragsdale. 2008. Water insecurity and emotional distress: Coping with supply, access, and seasonal variability of water in a Bolivian squatter settlement. *Social Science & Medicine* 67 (12): 2116–25.

WENDY JEPSON is an Associate Professor in the Department of Geography at Texas A&M University, College Station, TX 77845. E-mail: wjepson@tamu.edu. Her research interests include water governance, political ecology, and environmental justice with an empirical focus on Mexican-American communities on the U.S.–Mexico border.

EMILY VANDEWALLE is a former graduate student in the Department of Geography at Texas A&M University, College Station, TX 77845. E-mail: emily.vandewalle@gmail.com. Her research interests include water governance, public health, and environmental justice.