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Perceived water safety and elevated liver enzymes in rural West Virginia: links between drinking water, beverage habits, and liver health

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Abstract

Introduction: In rural communities, aging infrastructure and environmental challenges can contribute to mistrust in tap water, potentially influencing hydration behaviors and health outcomes. The relationship between perceived water safety and liver health remains underexplored, particularly in low-resource Appalachian settings in the US.

Methods: This cross-sectional study examined data from 272 adult patients in a primary care clinic in rural West Virginia, US. Participants rated their home tap water safety on a seven-point scale and reported beverage consumption patterns in a survey. Clinical indicators were abstracted from the electronic health record, including alanine aminotransferase (ALT), aspartate aminotransferase (AST), hemoglobin A1c (HbA1c), BMI, and diagnosis of metabolic dysfunction-associated steatotic liver disease (MASLD). Descriptive and inferential statistics were used to evaluate associations between perceived water quality and health indicators.

Results: One-third of participants rated their home tap water safety as low. While no significant association was found between water perception and a known diagnosis of MASLD, liver enzyme elevations were significantly more common among those with poor water perceptions. ALT>40 U/L was present in 58.82% of participants with low water safety perception, compared to 31.47% of those reporting higher water safety ($\chi^2(1)=5.24$, $p=0.022$; odds ratio (OR)=3.11, 95% confidence interval (CI): 1.13–8.55). A similar pattern was observed for AST>40 U/L ($\chi^2(1)=4.67$, $p=0.031$; OR=3.73, 95%CI: 1.06–13.08). No statistically significant relationships were found with HbA1c or BMI. Despite concerns about tap water, most participants reported moderate or low sugar-sweetened beverage (SSB) consumption, and 68.5% drank unfiltered tap water at least occasionally.

Discussion: Findings suggest that lower perceived water quality was associated with elevated liver enzymes, even in the absence of diagnosed disease. These associations should be interpreted as exploratory but suggest that perceived or actual environmental stressors may coincide with hepatic changes. In regions with aging or unregulated municipal systems, individuals expressing lower water safety perceptions may also experience recurring water disruptions or exposure concerns, highlighting a complex intersection of infrastructure, perception, and health. Importantly, no substitution effect was observed between unsafe water perceptions and high SSB intake.

Conclusion: Understanding how local hydration behaviors intersect with environmental perceptions is essential to designing effective public health interventions. Community-centered efforts that improve transparency in water quality reporting, support affordable filtration access, and address environmental and psychosocial stressors may strengthen chronic disease prevention and health promotion in rural and underserved areas.

Keywords

Appalachia, beverage consumption, liver enzymes, metabolic dysfunction-associated steatotic liver disease (MASLD), perceived water safety, sugar-sweetened beverages, US.

Introduction

Liver disease represents a growing global health burden, with metabolic dysfunction-associated steatotic liver disease (MASLD; previously non-alcoholic fatty liver disease or NAFLD) now the most common liver disease worldwide[1]. In both low- and middle-income countries and rural regions of high-income nations, structural and environmental factors, including limited access to safe drinking water, contribute to disparities in metabolic and liver health[2,3]. In such settings, mistrust in local water quality may lead individuals to rely on bottled or sugar-sweetened beverages (SSBs), behaviors linked to dehydration, excess caloric intake, and metabolic dysfunction[4-6]. MASLD affected an estimated 37.8% of the global population in 2022, up from 25.5% in 2005[4]. MASLD refers to a spectrum of conditions characterized by fat accumulation in the liver not caused by alcohol or medication use[5]. Most individuals with MASLD are unaware of their condition, which is often asymptomatic in its early stages[6]. Without intervention, MASLD can progress to more severe conditions such as non-alcoholic steatohepatitis, fibrosis, cirrhosis, and hepatocellular carcinoma. While liver biopsy remains the gold standard for diagnosis, it is rarely feasible for routine care, especially in rural or underserved settings.

Instead, elevated liver enzymes such as alanine aminotransferase (ALT) and aspartate aminotransferase (AST) are often used as early clinical indicators[7]. West Virginia, a predominantly rural US state, offers a unique context for studying MASLD due to its intersecting environmental and socioeconomic challenges. Many communities in West Virginia rely on unregulated water systems, including well water that may be contaminated. In McDowell County, for example, residents lived under a boil water advisory for over a decade and continue to face persistent issues with water access and quality[8,9]. These longstanding infrastructure problems have contributed to deep mistrust in local water systems[10]. That mistrust may shape beverage choices, with some individuals turning to bottled beverages or SSBs instead of drinking tap water[11]. West Virginian adults report among the highest rates of daily SSB consumption in the US, with 39.2% consuming these drinks each day[12]. SSB intake has been linked to increased risks for weight gain, metabolic disorders, and liver disease[4,13].

While MASLD often coexists with other metabolic conditions – 70–80% of individuals with diabetes are also affected[5] – it can also develop independently, in the absence of other diagnoses[6]. The condition represents a growing public health concern, not only due to its rising prevalence but also because of its potential to progress to cirrhosis and hepatocellular carcinoma. Although strong evidence links insulin resistance, obesity, and other markers of metabolic dysfunction to the development of MASLD[14], relatively few studies have explored how environmental or behavioral factors may contribute – particularly in rural populations.

Rural and minority populations face additional challenges related to water access, healthcare availability, and economic hardship, which may compound health disparities[15]. Negative perceptions of tap water safety have been associated with significantly higher odds of daily SSB consumption, particularly among Hispanic adults[16]. Similarly, a qualitative study of rural communities found that youth often substituted bottled or sweetened beverages for tap water when they perceived the water as unsafe[17]. These findings suggest that perceived water quality may influence beverage choices, especially in underserved or environmentally vulnerable populations. In rural West Virginia, environmental stressors, including reliance on unregulated water sources, may encourage greater SSB consumption as an alternative to drinking tap water.

Water-related environmental exposures may plausibly influence liver biomarkers through several mechanisms. Reviews have linked contaminants found in drinking-water systems – including per- and poly-fluoroalkyl substances (PFAS), heavy metals, disinfection by-products, and algal toxins – to steatosis, hepatocellular injury, and altered liver enzymes via oxidative stress, endocrine and lipid-metabolism disruption, and mitochondrial effects[18]. Emerging environment-wide analyses also report associations between diverse environmental chemicals and elevated liver enzymes at the population level[19]. In Appalachia, reported daily water intake is lower than national averages, which may reflect substitution of SSBs or bottled beverages for tap water[20]. Given these pathways, and the regional context of Appalachian communities, examining perceived water safety alongside liver enzymes is reasonable while recognizing that contaminants were not measured in this study.

This study explores the relationship between perceived drinking water quality, beverage consumption patterns, and biomarkers of liver health in rural residents of West Virginia. Understanding how environmental perceptions shape health behaviors may help inform patient-centered interventions to prevent and manage chronic diseases, including MASLD.

Methods

Study design and setting

This cross-sectional study was conducted at Tug River Health Association clinics located in Wyoming and McDowell Counties, West Virginia, two rural Appalachian communities facing longstanding infrastructure and health challenges. Tug River Health Association provides comprehensive primary care services to approximately 6000 patients annually, including family medicine, women's health, addiction treatment, pediatrics, dental care, and urgent care. Survey administration took place during clinic hours over several designated days. These sites were selected for their relevance to the study aim, given their patient population's exposure to both healthcare access barriers and environmental water concerns.

Participants

Eligible participants were adult patients (aged 18 years or older) who presented for primary care services at participating Tug River locations on designated survey days. There were no exclusion criteria based on medical history or diagnosis. Participation was voluntary, and no incentives were offered. After receiving a brief explanation of the study, patients could complete the survey independently on a tablet or with the assistance of a trained medical student. Surveys were typically completed while patients waited in the exam room to see their provider. The survey was offered to adult patients as part of routine clinical workflow using a convenience sampling approach consistent with practice-based research design. Because recruitment occurred within the flow of care, the number of patients offered participation was not recorded, and a formal response rate could not be calculated.

Data collection

The survey instrument, created in Qualtrics (https://www.qualtrics.com), assessed participants' perceptions of their home tap water quality and detailed their beverage consumption patterns, including intake of SSBs. Survey responses were securely stored on the Qualtrics cloud platform. After survey completion, clinic staff or medical student assistants abstracted relevant clinical data from the electronic health record, including ALT, AST, hemoglobin A1c (HbA1c), and BMI. The complete survey instrument, including all question wording and response options, is available in Appendix I.

Statistical analysis

Descriptive statistics were used to summarize demographic characteristics, beverage consumption, and clinical indicators. For continuous variables (ALT, AST, HbA1c, BMI), means, medians, standard deviations (SDs), and quartiles were calculated. Frequencies and proportions were reported for categorical variables such as demographics, water safety perception, and MASLD diagnosis. Associations between perceived water safety and health outcomes (MASLD diagnosis, elevated ALT or AST, HbA1c ≥6.5%, BMI ≥30 kg/m^2) were evaluated using χ^2 tests based on 2×2 contingency tables. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to estimate effect sizes. To explore potential confounding by obesity, additional χ^2 analyses compared the prevalence of elevated liver enzyme levels (ALT and AST >40 U/L) among participants with BMI≥30 versus those with BMI<30. Odds ratios were defined as the odds of each adverse outcome among participants with low water safety perception (<4 on the seven-point scale) relative to those with moderate/high perception (≥4). Pairwise complete cases were used for each outcome; therefore, denominators vary across analyses. Statistical significance was set at $p<0.05$. All analyses were conducted in JMP Pro v18 (SAS Institute; https://www.jmp.com). Logistic regression was considered to calculate adjusted ORs but was not feasible due to the small number of participants with certain outcomes. Because there were too few cases of elevated liver enzymes and other conditions, adjusted models would not have produced reliable estimates. For this reason, only unadjusted (crude) ORs are reported.

Ethics approval

This study was reviewed and approved by the West Virginia University Institutional Review Board (Protocol #2008080197). Informed consent was obtained from all participants prior to data collection. All data were de-identified and stored securely to protect participant confidentiality.

Results

Participant characteristics

A total of 272 participants from rural southern West Virginia were included in the study. The sample was predominantly middle-aged and older adults; nearly half (48.53%) were aged between 46 and 65 years, and 23.16% were over the age of 65 years. Most participants identified as female (68.75%), while 30.88% identified as male. Racial demographics reflected regional patterns: 86.76% identified as White, and 11.76% as Black or African American. The majority (75.37%) reported using city or municipal water as their primary household water source, while 16.91% relied on well water and 5.15% used spring or mountain water. A few participants indicated no running water or uncertainty about their water source, emphasizing disparities in water infrastructure access in rural West Virginia (Tables 1, 2).

Table 1: Demographic characteristics of the study participants (*N*=272), including age distribution, sex, race, ethnicity, and household income

Characteristic	Variable	Number (*n*)	Percentage (%)

Age group (years)	<25	20	7.35
	25–45	57	20.96
	46–65	132	48.53
	>65	63	23.16
Gender	Female	187	68.75
	Male	84	30.88
	Other	1	0.37
Race	White	236	86.76
	Black or African American	32	11.76
	American Indian or Alaska Native	1	0.37
	Other/multiracial	1	0.37
	Prefer not to answer	2	0.74
Hispanic or Latino ethnicity	No	260	98.48
	Prefer not to answer	4	1.52

Table 2: Overview of primary water sources used by study participants (*N*=272)

Water source	Number (*n*)	Percentage (%)
City/municipal water	205	75.37
Well water	46	16.91
Spring or mountain water	14	5.15
Other (eg cistern, pumped)	4	1.47
Unsure	3	1.10
No running water at home	1	0.37

Health profile and laboratory measures

Most participants (87.97%) reported no history of chronic liver conditions, although 9.77% indicated a diagnosis of MASLD. Other liver conditions were uncommon. These self-reported diagnoses provide context for the subsequent laboratory assessments. (Table 3). Laboratory findings showed a mean ALT of 23.97 U/L (SD=18.99) and a mean AST of 24.01 U/L (SD=19.78). Mean HbA1c was 6.52%, with the upper quartile reaching 7.05%, suggesting elevated risk for prediabetes or diabetes. BMI levels indicated widespread obesity, with a mean BMI of 35.43 kg/m². Notably, 75% of participants had a BMI greater than 29.1 kg/m², and the 90th percentile reached 46.62 kg/m² (Table 4).

Table 3: Health conditions and laboratory findings for study participants

Condition†	Variable	Number (*n*)	Percentage (%)¶
Acute viral hepatitis (past year)	No	271	98.55
	Yes	4	1.45
Chronic liver condition	None	234	87.97
	MASLD	26	9.77
	Chronic hepatitis C	4	1.50
	Primary biliary cirrhosis	1	0.38
	Other	1	0.38

† Conditions are not mutually exclusive.
¶ Percentages are based on available responses, and denominators vary due to non-response for some items.
MASLD, metabolic dysfunction-associated steatotic liver disease (previously non-alcoholic fatty liver disease).

Table 4: Clinical laboratory measures related to liver function (ALT, AST), metabolic regulation (HbA1c), and BMI as an indicator of obesity†

Measure	*n*	Mean	SD	Median	Minimum	Maximum
ALT (U/L)	224	23.97	18.99	20	6	180
AST (U/L)	225	24.01	19.78	20	8	196
HbA1c (%)	173	6.52	1.87	5.90	4.70	16
BMI (kg/m^2)	247	35.43	13.45	33.18	19.4	199.2

† Although mean ALT and AST levels were within normal ranges, elevated values were observed for some participants.
ALT, alanine aminotransferase. AST, aspartate aminotransferase. HbA1c, hemoglobin A1c. SD, standard deviation.

Perceived water quality and clinical indicators

Perceptions of water safety varied, with 33.98% of participants rating their home water as unsafe or low in safety (scores 1–3 on a seven-point scale) (Table 5). To explore relationships between water safety perception and health outcomes, bivariate analyses were conducted across key biomarkers. Significant statistical associations were observed for liver enzymes. Participants with elevated ALT (>40 U/L) had higher odds of reporting low water safety perception (<4) compared with those with normal ALT (58.82% v 31.47%, $\chi^2(1)=5.24$, $p=0.022$; OR=3.11, 95%CI: 1.13–8.55). A similar association was found for AST: 9.72% of those with low water safety perceptions had elevated AST (>40 U/L), compared to 2.82% among those reporting higher water safety

($\chi^2(1)=4.67$, $p=0.031$; OR=3.73, 95%CI: 1.06–13.08). No statistically significant associations were found between perceived water safety and HbA1c ≥6.5% or BMI ≥30 kg/m². Participants who perceived their water as unsafe were slightly less likely to have elevated HbA1c or obesity, although these differences were not statistically significant (all $p>0.40$) (Table 5).

Additional analyses examined potential confounding by obesity. Elevated ALT was observed in 7.9% of participants with BMI≥30 and 7.5% with BMI<30 ($\chi^2=0.012$, $p=0.91$; OR=1.06, 95%CI: 0.36–3.15). Elevated AST was observed in 3.9% of participants with BMI≥30 and 7.5% with BMI<30 ($\chi^2=1.23$, $p=0.27$; OR=0.51, 95%CI: 0.15–1.72). These results indicate no statistically significant differences in liver enzyme elevations by BMI category.

Table 5: Association between water safety perception and health outcomes

Outcome	Water safety perception	Outcome = yes	Outcome = no	Total *n*	Percentage with outcome (%)[†]	χ^2 (*p*)	Odds ratio[¶] (95%CI)
MASLD diagnosis	Low (<4)	9	78	87	10.3	0.032 (0.858)	1.08 (0.46 – 2.56)
	Moderate/high (≥4)	16	150	166	9.6		1.00 (reference)
ALT >40 U/L	Low (<4)	10	63	73	13.7	5.24 (0.022)	3.11 (1.13 – 8.55)
	Moderate/high (≥4)	7	139	146	4.8		1.00 (reference)
AST >40 U/L	Low (<4)	7	65	72	9.7	4.67 (0.031)	3.73 (1.06 – 13.08)
	Moderate/high (≥4)	4	138	142	2.8		1.00 (reference)
HbA1c ≥6.5%	Low (<4)	16	39	55	29.1	0.67 (0.414)	0.74 (0.37 – 1.49)
	Moderate/high (≥4)	39	71	110	35.5		1.00 (reference)
BMI ≥30 kg/m^2	Low (<4)	58	24	82	70.7	0.19 (0.663)	1.13 (0.64 – 2.01)
	Moderate/high (≥4)	104	49	153	68.0		1.00 (reference)

[†] Denominators vary by outcome due to pairwise missing data for perception or laboratory values.
[¶] Odds ratios compare the odds of each adverse outcome among participants with low water safety perception relative to those with moderate/high perception (reference group).
ALT, alanine aminotransferase. AST, aspartate aminotransferase. CI, confidence interval. HbA1c, hemoglobin A1c. MASLD, metabolic dysfunction-associated steatotic liver disease (previously non-alcoholic fatty liver disease).

Beverage consumption patterns

Despite concerns about water quality, water remained the primary hydration source for many participants, with 64.96% reporting regular consumption. Bottled water was preferred over tap water: 68.48% of participants reported that they did not regularly drink unfiltered home tap water. SSB consumption was moderate: 41.90% reported drinking regular soda occasionally or frequently, typically in 12 oz (355 mL) servings. Coffee with milk or creamer was commonly consumed, with 50.5% reporting regular use. Alcohol use was low; 94.42% reported no regular alcohol intake (Table 6).

Table 6: Beverage consumption patterns of study participants

Beverage	Regular (≥1 per week) (%)[†]	Daily (≥1 per day) (%)[†]	Non-consumer (%)[†]
Unfiltered tap water	21.14	8.53	68.48
Filtered or boiled tap water	17.44	8.72	72.80
Bottled water (non-flavored)	49.41	34.78	17.05
Bottled sugar-free flavored water	27.30	8.72	63.35
Sugar-sweetened drinks (with home tap water)	15.07	3.16	79.76
Regular soda	41.90	29.25	28.85
Coffee with milk or creamer	50.50	13.20	36.30
Alcoholic drinks	4.80	0.80	94.42

[†] Based on available responses for each beverage item.

Discussion

This study examined the relationship between perceived water quality, beverage consumption patterns, and indicators of liver and metabolic health. A significant association was observed between lower water quality perceptions and elevated liver enzyme levels. Participants with ALT >40 U/L were over three times more likely to rate their water quality as poor (<4), with an odds ratio of 3.11 (95%CI: 1.13–8.55). A similar pattern was observed for AST >40 U/L (OR=3.73; 95%CI: 1.06–13.08), suggesting a statistical association between environmental concerns and early liver stress. In contrast, no statistically significant associations were found between water safety perceptions and HbA1c ≥6.5%, BMI ≥30 kg/m², or self-reported MASLD diagnosis. Participants with a known diagnosis of MASLD did not differ significantly in their perceptions of water quality, indicating that diagnostic status alone was not associated with water-related concern in this sample.

Beverage consumption data provided further insight into hydration behaviors. Despite concerns about water safety, 68.48% of participants reported drinking unfiltered, untreated (ie neither filtered nor boiled) tap water at least occasionally, and over a third of participants reported daily bottled water intake (34.78%). SSB consumption was generally moderate: 79.76% reported no regular consumption of SSBs made with home tap water, and 41.90% reported regular soda consumption (≥1 per week).

These results add to existing literature on environmental perceptions and health behaviors in rural and underserved settings. Prior studies in low-resource areas have linked poor tap water perceptions with increased SSB consumption and related health risks. In contrast, findings from this study suggest that, although water safety concerns were present, high-sugar beverage substitution was not evident. Most participants reported moderate-to-low intake of soda, flavored juices, and energy drinks. This pattern may reflect existing health awareness, economic limitations, or local cultural preferences.

The observed association between water safety perceptions and elevated ALT and AST levels is consistent with emerging evidence suggesting that psychosocial stressors and environmental exposures can coincide with hepatic abnormalities. However, these results should be interpreted as exploratory correlations rather than evidence of a direct causal pathway. Additional research is needed to clarify whether these associations reflect physiological effects of environmental contaminants, stress-related responses, or other unmeasured factors. Because this was an exploratory study, it remains unclear whether the observed relationship reflects physiological effects of contamination, psychological stress responses, or a combination of both.

Findings from this analysis suggest that participants who expressed greater concern about water safety also had higher odds of elevated liver enzyme levels, even in the absence of clinically diagnosed MASLD. This pattern underscores the importance of distinguishing between formal diagnoses and underlying biomarker variation. The lack of significant associations with HbA1c or BMI suggests that the link between water safety perception and liver enzymes may be context-specific or influenced by localized environmental and social conditions. Broader cumulative factors in rural settings, such as environmental degradation, poverty, or gaps in preventive care access, may also contribute to variations in liver function markers over time.

Public health initiatives that address both actual and perceived water quality could have benefit for rural communities. Potential strategies include improving transparency in water quality reporting, expanding access to affordable filtration systems, and strengthening public trust in local water infrastructure. Continued education around hydration and beverage choices also remains important, given that moderate levels of SSB intake persisted among participants in this study.

Several limitations should be noted. The study relied on self-reported data, introducing potential recall or social desirability bias. The sample was drawn from one rural region of West Virginia, which may limit generalizability. Because recruitment occurred within routine clinic workflow using a convenience sampling approach, the number of patients offered participation was not tracked, and a formal response rate could not be calculated. Environmental contaminants and hydration status were not measured; therefore, the specific exposures underlying the observed associations cannot be determined. Due to the cross-sectional design, causal relationships between water perception, beverage consumption, and MASLD-related health markers cannot be inferred. While the sample was sufficient for exploratory analyses, small subsample sizes for some comparisons (eg participants with ALT>40 U/L) may have reduced statistical power. The limited number of participants with certain outcomes also prevented adjustment for other factors such as age, sex, or BMI. Logistic regression was therefore not feasible, and the odds ratios presented are unadjusted and should be interpreted with this limitation in mind.

Further research is needed to assess whether shifts in water safety perception over time influence liver health biomarkers. A longitudinal design could help determine whether perceived or actual water contamination contributes to disease progression. Future work should also include direct measurement of drinking-water contaminants, such as PFAS, heavy metals, disinfection by-products, or algal toxins, to clarify potential biological pathways linking environmental exposures to hepatic function. Broader environmental assessments examining household or community air quality, housing conditions, and co-occurring health outcomes such as kidney disease would provide a more comprehensive view of environmental determinants of metabolic and hepatic health. Expanding to include multiple rural health systems would improve generalizability and allow for identification of regional disparities. Finally, incorporating qualitative methods, such as using interviews or focus groups, could complement quantitative analyses by exploring local water perceptions and any coping behaviors. While such approaches would not directly establish biomedical pathways linking water quality to health outcomes, they would help contextualize perceptions and inform future study design.

Conclusion

This study highlights the intersection of beverage consumption patterns, perceived water safety, and liver health in rural West Virginia. While no significant association was observed between water safety perceptions and diagnosed MASLD, liver enzyme elevations were more common among participants reporting lower water safety. Because MASLD is frequently underdiagnosed, these findings may reflect early changes in liver function rather than overt disease. The observed association likely extends beyond perception alone. In many rural communities with aging or unregulated water systems, residents routinely experience water outages, boil advisories, and contamination concerns. Individuals expressing low water quality ratings may live in areas where such infrastructure failures are most frequent, raising the possibility of both direct and indirect health effects. Future research should assess measured contaminant exposures and other environmental stressors to better clarify these pathways.

No significant associations were found between water safety perceptions and HbA1c or BMI, and most participants reported only moderate consumption of SSBs, suggesting that hydration behaviors in this population are influenced by a combination of perception, access, and routine rather than a simple substitution with sugary beverages.

Understanding how local hydration behaviors intersect with environmental perceptions is essential for designing effective community-centered interventions. Strategies that acknowledge lived experience, promote transparency around water quality, and rebuild trust in safe drinking water systems may offer an important pathway to improved chronic disease prevention and quality of life in rural settings.

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Conflicts of interest

The authors declare no conflicts of interest.

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Appendix I: Survey instrument – perceived water quality, beverage consumption, and liver health

Survey question	Response options
Anonymous survey consent	Yes/No. Consent text described the voluntary and anonymous nature of participation, inclusion criteria (≥18 years), and study purpose. Completion of the survey implied consent.
1. Acute viral hepatitis	'Have you been diagnosed with acute viral hepatitis (A or B) in the past year?' Yes / No *(if Yes → end survey)*
2. Chronic liver conditions	'Do you currently have any of the following chronic liver conditions? (Select all that apply.)' Chronic HBV / HCV / Alcoholic liver disease / metabolic dysfunction–associated steatotic liver disease / non–alcoholic steatohepatitis / Autoimmune hepatitis / Primary biliary cirrhosis / Other / None
3. Type of tap water at home	City (municipal) / Well / Spring or mountain / No running water / Unsure / Other
4. Perceived tap water safety	7–point scale: 1 = *Extremely dangerous* → 7 = *Extremely safe*
5. Do you drink your tap water?	Yes (unfiltered / filtered / boiled / filtered + boiled) / No
6. Non–alcoholic beverages – frequency	'For each beverage, indicate how frequently you drink it.' Options: N/A / 1–3 x wk / 4–6 x wk / 1–10+ x day. Beverages: unfiltered tap water; filtered tap water; bottled water; bottled sugar–free flavored water; sugar–free mix drinks; sugar–sweetened drinks made with tap water
7. Non–alcoholic beverages – serving size	For beverages above: 8 oz / 10 oz / 12 oz / 16 oz / 20 oz / 32 oz or more
8. All beverages – frequency	'For each beverage, indicate how frequently you drink it.' Options: N/A / 1–3 x wk → 10+ x day. Beverages: water or unsweetened sparkling water; 100 % fruit juice; sweetened juice beverages; regular and low–fat milk types; flavored and unsweetened nut milks; regular and diet soft drinks; energy and sports drinks; sweet tea; tea/coffee (black or with milk/creamer); wine; hard liquor; beer/wine coolers
9. All beverages – serving size	For items above: < 8 oz / 8 oz / 10 oz / 12 oz / 16 oz / 20 oz / 32 oz or more
10. Additives in tea or coffee	'What do you usually put in your tea and/or coffee?' None / Black only / Sugar / Artificial sweetener / Milk / Half & Half or cream / Regular creamer / Sugar–free creamer / Flavored creamer
11. Other beverages	Open–ended: 'Do you drink any beverage not listed? If yes, specify type, frequency, and usual serving size.'
12. Regular versus diet soft drinks	I do not drink soda / Diet / Regular (pop, soda, soft drink)
13–15. Brand preferences	Rank–order favorite regular or diet soft–drink brands (eg Mountain Dew, Coke, Pepsi, Dr Pepper variants)
16. Sex	Male / Female / Other (specify) / Prefer not to answer
17. Race	American Indian / Asian / Black / Pacific Islander / White / Other (specify) / Prefer not to answer
18. Ethnicity	Hispanic or Latino / No / Prefer not to answer
19. Age category	Under 12 / 12–15 / 15–21 / 21–25 / 25–30 / 30–45 / 45–55 / 55–65 / >65 / Prefer not to answer
20. Household income	<$10 k / $10–20 k / $20–30 k / $30–45 k / $45–60 k / $60–85 k / >$85 k / Prefer not to answer
21. Household size	Open numeric entry
22–26. Clinical data (to be completed by staff)	Most recent laboratory results within past year: ALT (U/L) / AST (U/L) / Hemoglobin A1c (%) / BMI (kg/m^2)

ALT, alanine aminotransferase. AST, aspartate aminotransferase. HbA1c, hemoglobin A1c. HBV, hepatitis B. HCV, hepatitis C.