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The Triple Burden: Tramadol, NSAIDS, and Energy Drinks Among Agricultural Workers in La Gomera, Guatemala: An Anthropological Study

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ABSTRACT

Introduction: Agriculture is a major economic activity in Guatemala. Workers in sugarcane, banana, and African palm plantations face high risk of chronic kidney disease of non-traditional causes (CKDnT). During 2021– 2023, Médecins Sans Frontières (MSF) implemented a project in Guatemala to provide comprehensive care for CKDnT. The frequent use of potentially nephrotoxic substances, such as medications and energy drinks, was documented. This qualitative study, conducted during 2023, aimed to understand this practice and its relation to agricultural work.

Methods: Interviews, focus group discussions, and pile sorting technique were implemented for data collection. Participants ($n = 24$) were plantation workers ($n = 13$), supervisors ($n = 5$), labor authorities ($n = 2$), and healthcare staff ($n = 4$). Interviews were audio-recorded and transcribed. Deductive and inductive thematic analysis was performed using NVivo.

Results: Three core themes emerged: (1) substances, motivations, practices of use, and availability, with tramadol, energy drinks, and non-steroidal anti-inflammatory drugs commonly consumed in various ways (drunk, swallowed, inhaled, or spread on cigarettes to be smoked) to sustain labor; (2) work dynamics and its relation to the use of substances; and (3) perception of health risks related to the use of substances.

Discussion: Piecework payment systems incentivize high production, framing substance use as a necessity to increase energy and manage pain and fatigue. Use of medications and other substances was described as socially accepted and normalized. Addressing CKDnT requires structural interventions and culturally adapted health promotion strategies.

Conclusion: Agricultural work dynamics in Guatemala contribute to the use of medications and substances that influence agricultural workers health. Structural causes, including factors such as poverty, instability, and social dynamics, further hinder substance discontinuation. Further interdisciplinary research is needed to deepen the understanding of this practice and its relationship with the high prevalence of CKDnT.

KEYWORDS

Agricultural workers; chronic kidney disease of non-traditional causes; health risks; tramadol

Introduction

Agriculture is one of the main economic activities in Guatemala,[1,2] a top global exporter of sugarcane, banana, and African palm.[3] However, agricultural workers face significant health risks, including injuries, dehydration, work accidents,[4] and chronic kidney disease of non-traditional causes (CKDnT).[5–8,9,10] Factors common in this work, such as heat stress, dehydration, and exposure to agrochemicals, nephrotoxins, and pesticides are linked to CKDnT.[6,7,11–14]

The use of steroidal and non-steroidal anti-inflammatory drugs (NSAIDs), antibiotics, and diuretics, is also suspected to be related to CKDnT.[15] Several nephrological complications, such as acute kidney injury and chronic kidney disease (CKD), have been associated with the overuse of NSAIDs.[16] The use of NSAIDs can cause the blood vessels in the kidneys to narrow instead of opening to maintain blood flow, leading to kidney damage, especially when agricultural workers are exposed to extreme heat and severe dehydration.[17] However, the potential

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relation relationship between the use of NSAIDs and other medications with CKDnT remains unclear.

The high prevalence of CKDnT is a health crisis that affects agricultural workers in hot climates across different contexts, including Central and Latin America[18,19] and South Asia.[20,21] The increasing number of people with this disease is related to shared vulnerabilities among different contexts, such as extreme heat and precarious labor conditions.[10,22–25]

Between 2021 and 2023 Médecins Sans Frontières (MSF) developed a comprehensive care model for CKDnT in La Gomera, La Democracia and Sipacate, three rural municipalities in Escuintla, one of the 22 departments of Guatemala, located on the southern coast of the country. The main economic activity in Escuintla is agriculture, especially on banana, African palm and sugarcane plantations.[26] Escuintla is also one of the departments with the highest prevalence of CKDnT and CKD in the country.[8] During project activities, MSF staff documented the high use of potentially nephrotoxic substances (PNS), such as steroids and NSAIDs, among agricultural workers and the overall population of the three communities.

The use of medications such as tramadol and NSAIDs has been documented among agricultural and farm workers in other global contexts, such as Thailand[27–33] and Ghana.[33] In Latin America, particularly Guatemala, scientific evidence on the use of medications and its relationship with working conditions is scarce. While two studies reported this practice in Guatemalan agricultural areas,[34,35] research about the use of medications and other substances to increase energy for higher productivity and better pay remains a priority gap.[15,17]

Understanding the use of PNS and its relation with CKDnT requires an approach rooted in the social determinants of health,[28,36] especially given the structural factors involved, like demands for overproduction and lack of protection.[37–41] To address this, an anthropological study was conducted in La Gomera, La Democracia and Sipacate, to understand the practices, social and cultural meaning of using tramadol, beverages and other medications, and their link to agricultural work.

Methods

Data collection included semi-structured interviews and focus group discussions (FGDs). Interviews and FGDs guides included the same questions, with adapted questions for worksite supervisors, labor authorities and healthcare staff according to their field of expertise. The interview guides explored daily work routines, motivations for substance use, perceived effects and potential health risks. To stimulate conversation around the core topics of the interview and FGD guides, we used the drug bag method,[42] an adaptation of the pile sorting technique,[43] where participants were asked to interact with 14 printed images of the medications and drinks documented by MSF staff as commonly used by local workers. Images were put in front of participants during conversations, and they were invited to use them to explain their perspectives, knowledge and experiences.

Participants were recruited using snowball sampling, starting with patients from MSF's care points in the three communities. Interviews were conducted at the time and location chosen by participants, who provided informed consent for participation and audio recording.

Interviews and FGD were conducted in Spanish by a multidisciplinary team, comprised by MSF health promoters (trained in data collection and ethics) and authors DGL, FO, and SH. The multidisciplinary character of the research team was instrumental in building trust and rapport with the agricultural workers. However, the researchers remained consciously aware that being perceived as representatives of an international humanitarian medical organization could have influenced participants' responses. Data collection took place from October to December 2023 and concluded when thematic saturation was reached, defined as the point where no new themes emerged across the different participants profiles.[44] Interviews and FGD lasted an average of 60 minutes (ranging from 20 to 90 minutes).

All interviews and FGD were transcribed verbatim in Spanish and reviewed by the research

team for accuracy. The testimonies used in this article were translated from the original into English.

The data for this analysis were drawn from a broader qualitative study examining the use of medications and other PNS in agricultural communities in Escuintla, Guatemala. While previously published work from this study explored the medication and beverage consumption habits among community members overall, the present study focuses on understanding how precarious labor conditions shape this practice and the individualization of health risks among agricultural workers.[35] Thematic analysis, following the six-phase Braun and Clarke approach,[45,46] was performed using NVivo by authors DGL and ME. Periodic meetings were held during data collection and analysis to discuss the implications of the findings, as well as to refine the analysis and reflect on potential biases that might shape the interpretation of narratives. To mitigate analytical bias and ensured that interpretations remained grounded in the participants lived experiences, the coding process was continuously discussed among research team members. The analysis applied deductive codes derived from the study objectives which included: substances and availability, perceived motivations and effects, use practices, work culture, and perceived health risks. Furthermore, inductive codes were generated during the analytical process to capture new themes emerging from the data such as mitigation practices, peer pressure, body as a tool, individualization and traditional medicine practices. The results of the inductive phase are fully integrated into the Results section, structured by three main themes: substances, motivations, practices of use and availability; work dynamics and its relationship to the use of substances; and perception of health risks.

Due to the logistical constraints of the MSF intervention, which resulted in the closure of the Escuintla project prior to the completion of the final analysis, comprehensive member checking could not be conducted with all participants. However, preliminary findings and identified themes were shared with groups of participants during meetings. The feedback provided by these attendees was subsequently incorporated into the final analysis to enhance the validity of our interpretations.

Ethical approval was obtained from MSF Ethical Review Board (ID: 2343) and the National Committee of Health Ethics of Guatemala's Ministry of Public Health (Protocol number 21–2023).

Results

Participants in interviews included plantation workers ($n = 7$):sugarcane ($n = 4$), banana ($n = 2$) and African palm ($n = 1$), worksite supervisors ($n = 5$), labor authorities ($n = 2$), and worksite health staff ($n = 4$). One FGD was conducted, with six African palm plantation workers who were entirely distinct from the individual interviewed. Although FGD were originally planned for sugarcane and banana workers as well, the research team was unable to organize them due to scheduling conflicts during data collection period.

The thematic analysis yield three primary themes that capture the agricultural workers and other actors' experiences and perspectives regarding the use of medications and drinks to enhance energy. These themes are: 1) substances, motivations, practices of use and availability; 2) work dynamics and their relation to the use of substances; and 3) perceptions of health risks related to the use of medications and other substances.

Substances, motivations, practices of use and availability

The first theme details the specific medications and energy drinks consumed, the high availability and easy access to them through formal and informal vendors, and the main motivations for use as informed by participants.

The broad spectrum of medications and beverages reported as known, and sometimes consumed, by participants, is summarized in Table 1. Participants' accounts revealed distinct use patterns: medication was described both as a routine, often daily practice to prevent physical exhaustion or pain, and as an "as-needed" strategy to manage acute pain or exhaustion.

Table 1. Substances and medications reported*.

Use reported†	Common names / brands†	Substance†	Type†
Painkillers	Ibuprofen		Nonsteroidal Anti-inflammatory Drugs
	Diclofenac		
	Caplin	Acetaminophen	Analgesic
	Acetaminophen		
	Aspirin	Acetylsalicylic acid	Salicylate
	Aspirin Forte	Acetylsalicylic acid + caffeine	
Energy enhancers	*Tramal*	Tramadol	Opioid
	Tramadol		
	Acción plus	Acetaminophen + caffeine	Analgesic
	Sin sueño	Caffeine + thiamine	Energizing supplement
	Cerebrol	Piracetam	Nootropic
	Axcion	Phentermine	Anorexigen
	Naloxone‡		Opioid antagonist
	Alprazolam‡		Benzodiazepines
	Diazepam‡		
	Beta 2 Pan	Bisphosphonate + betamethasone propionate	Corticosteroid with anti-inflammatory effects
	Raptor	Energy drinks (taurine, caffeine, ginseng extract, guarana and B12 complex)	Beverage
	Amp		
	Adrenaline		
Restorative	Veterinary drugs (no name or brand mentioned by participants included in this analysis) ‡		
	Complejo B‡	Vitamins, usually B12	Supplement
	Vital Fuerte		
	Compleben‡		
	Sueros‡	Normal saline solutions	

* Table 1 is an adaptation of the one included in "*'The body is tired of so many pills'". Use and abuse of medications and drinks in agricultural communities in Escuintla, Guatemala"*, by Gómez-López et al 2026, SSM Qualitative Research in Health, https://doi.org/10.1016/j.ssmqr.2026.100821. Distributed under the terms of the Creative Commons CC-BY license.[35]

†The column "Reported use" refers to the use mentioned by the participants, although uses are not necessarily aligned to pharmaceutical or clinical recommendations; "Common brands and names" were the ones mentioned by participants; "Substance" and "Type" refers to information collected by researchers. Tramadol is included in two categories due to participants mentioning it being used for pain management and as an energy enhancer.

‡Although most substances listed in the table correspond to the ones shown during data collection when applying the pile sorting technique, some were spontaneously mentioned by participants.

Participants usually ingested these medications and beverages on their way to plantations or before starting work . While they typically swallowed pills and tablets whole, some mentioned crushing tramadol tablets or removing the enteric coating of pills, to be inhaled, swallowed or mixed with other substances. Less frequently, the use of drugs like marijuana and cocaine was also reported.

The most frequently reported motivations for medication use were pain management and increased energy, both of which support higher agricultural productivity. As one worker mentioned when taking tramadol:

> You don't get any sleep, you feel happy … you even undress to work, feel excited, don't feel hot nor the sun … you feel happiness and satisfaction in your body, knowing that you are also earning money. *Sugarcane cutter, interview*.

The seasonality of agricultural work (mainly for sugarcane plantations) is a key driver for this energy enhancement. Workers need to maximize earnings to ensure their savings are sufficient for household survival during periods of no income:

> I wanted to increase my income because I have two daughters, one in the university and other about to enter. I had to have the money for the whole year, not just for the four or five months that they give work during the harvest. I had to double that money … because the rest of the year there was no work. For example, during harvest season, from December to April, when you demand the most from your body, I normally consumed six capsules of each, six *Sin Sueño*, six pills of tramadol [generic name], six *Tramal* and six *Axciones* a day. *Sugarcane cutter, interview*.

Pain management was also one of the main motivations for consumption of tramadol or anti-inflammatories. Others mentioned that

medications were used to promote rest: *"I take two or three pills to sleep, either because I am tired or because I am worried, and I am instantly relaxed"* (banana packer, interview).

Medications and beverages are often mixed for consumption. Common mixtures include the *bomba* (a mix of carbonated and energy drinks, tomato juice, tramadol and other NSAIDs) or *elote loco* (a mixture of tramadol that is -either crushed tablets or the contents of capsules mixed- and toothpaste and smeared on a cigarette): "*I heard that they call it 'bomba', they mix three or four medications, put it in a Raptor and that is it. They call it champion's breakfast"* (worksite health staff, interview).

According to participants, medications and beverages are widely accessible in the area. Medications can be purchased in pharmacies and stores, usually sold as single units. *Chamorreros* (vendors selling food and beverages near or inside the plantations) also sell them to workers. One of the most common ways to access medications is through gifts among peers: "*that* [use of medications] *happens* [when they say] *'take one of these, it will give you more energy', one worker says to another and they try it and they feel the effect"* (worksite supervisor, interview).

The selling and consumption of pills and energy drinks are reportedly forbidden inside the plantations, and can result in fines, sanctions, or contract termination. Due to this ban, workers have reported smuggling these items onto the farms, camouflaged in their clothes or inside *pachones* (reusable bottles for hydration liquids). Some participants mentioned some items can be bought in plantation stores, as one said: "*Stores are controlled by the persons in charge. The bosses in the company sell them pills on credit, and they discount the cost to them on payday"* (worksite supervisor, interview).

As workers mentioned, supervisors can benefit from the crews' overproduction and have a higher income. Therefore, it is common for them to provide pills or energy drinks: *"Our boss provided us with the medicine because he also received some financial incentive*" (sugarcane cutter, interview). Prohibitions and sanctions are rarely enforced, and use is tolerated, as one participant pointed out: *"consumption is not encouraged but facilitated"* (health inspector, interview).

Cost of tramadol varies from 1 to3 Guatemalan quetzales (Q) (0.13 to 0.40 United States Dollars [USD]) for one pill, Q7 - Q10 (0.90–4 USD) for a blister pack of 10 pills, or Q60 - Q120 (7.8–15.6 USD) for a box of 100 pills, although the most common purchase is by unit. *Raptor*, the most common energy drink, is also available in volumes that go from 300 ml (Q3 or 0.40 USD per unit), 600 ml (Q5 or 0.65 USD), and 1,500 ml (Q22 or 2.90 USD). As reported, costs vary depending on the brand of the medication or the site of purchase, with those sold inside the plantations being more expensive than those in stores or pharmacies.

Work dynamics and its relation to the use of substances

This second theme highlights how the physically demanding nature of agricultural labor directly drives the use of these products to sustain physical exertion and ensure economic survival. Participants described working days characterized by strenuous physical activity, short periods of rest, and high productivity demands. This dynamic is common for cutters, pullers, irrigation managers, packers, and others working directly on the crop. Through pain management, increased strength, and energy, workers can manage their working day:

> If they got tired the day before, and the next day they arrive early [to work] they are ingesting it [medications and energy drinks] on the bus. It takes away their pain. In the morning, when they arrive at work, they have energy again. *Worksite supervisor, interview.*

Although in Guatemala there is a minimum wage for the working day, payments depending on the amount produced (piecework-based payment, locally known as *a destajo*), were commonly mentioned. As indicated by one woman employed on banana packaging, who gets paid Q0.50 per box of banana packed:

> They [employers] demand performance, because they cannot just pay you a minimum of 98 quetzales. They are not going to hire a person who is not going to perform because they will not pay you what you are not producing. They hire someone who they know is going to pack [the needed] boxes. I say: "with 200 boxes, I earn my salary". I am more relieved because I know that I earned it. *Banana packer, interview.*

The "champions system", where the most productive work crew or worker gets an additional reward, is another common practice. As one worker pointed out, these systems result in competitions: *"One does it* [using pills] *for money, to earn more, not to let your colleague beat you . . . is a competition between workers, I do not want this one to beat me, so I consume more* [medications]" (sugarcane cutter, interview).

Workers also referred to some benefits covered by the law, like the annual Bonus 14, that are conditional on productivity, as one mentioned:

> You can see the result [of high productivity] in the Christmas bonus and the bonus 14, because if you are a good packer and you packed more boxes, you will get your bonus and you bring extra [income], you bring more than the other workers. *Banana worker, interview.*

Besides its impact on income, not producing beyond the goals can be seen by peers as a fault, as one worker mentioned: "*some people start to call you names if you do not properly perform"* (African palm worker, FGD). Moreover, it can result in sanctions, that can be used as reason for contract termination, as one supervisor mentioned:

> If a worker did not reach his goal for the day, he must justify why. He writes a letter stating that he was feeling bad, his leg or arm was hurting or something . . . [in the office] they evaluate whether the person deserves salary adjustment, and if not, they would write a letter stating that the person was irresponsible . . . because he arrived late, the manager found him sitting down, took more time to eat . . . They will call him [the worker] and tell him: "there is no salary adjustment" and asked them to sign the note. There is no choice not to sign, you must do it. *Worksite supervisor, interview.*

Some workers attributed the origins of medication and energy drink use to the arrival of banana and sugarcane plantations in the area – approximately 10 years prior to the study – citing the greater physical demands of that crop as a driving force for the use of these substances: "*the cutters say they wouldn't last all day cutting sugarcane without their pills"* (worksite supervisor, interview). Others mentioned the use of substances was common decades ago, although the practice of combining multiple substances is more recent: *"people have worked years on banana plantations and the fatigue starts affecting them a lot"* (African palm worker, interview).

One participant mentioned, according to their experience, "*80% of workers use pills, another 10% use marijuana and the rest*, [consumes] *nothing"* (worksite supervisor). All participants agreed that the use of medications is a widespread and commonly practiced behavior. As one participant mentioned on the use of substances:

> It becomes something cultural, as we are seeing in this moment . . . is something that passes from generation to generation, something that kids live through. It's like family violence, dad hits mom, so I grow up and pass it to my family. *Worksite health staff, interview.*

While participants did not reach a consensus on which plantation (banana, palm or sugarcane) this practice was more prevalent, they did mention that the use of these substances spread from the plantations and is progressively more common among other community members. As one worker mentioned:

> Thank God the banana companies came, they created work opportunities for women too. But that happens, [the use of medications] not just in sugarcane, not just in the bananas. In any job, whether it's day labor, by the day, construction, whatever, they [workers] will bring their bottles and vials of Raptor and tramadol. *Sugarcane worker, interview.*

Finally, workers also mentioned the increased use of medications and energy drinks among young persons: "*some start [working] at 14, 15 years, because of the situation of the country, [money] is not enough"* (African palm worker, interview).

Perception of health risks related to the use of medications and other substances

The third theme examines how participants understand health consequences associated with

the overuse of medications and energy drinks, and the strategies they employ to mitigate these perceived harms. Participants mentioned some perceived health risks related to consuming medications and energy drinks. Some mentioned that accumulation of medications can damage the stomach. For that reason, some preferred capsules "*because the others are pure plaster that stay in the stomach and make you sick*" (sugarcane worker, interview). For others, enteric coating is considered damaging, as one pointed out:

> I told them [to his peers] 'that's rubber, you can't see', and I poured a little water on it and it got quite big, 'look how you can have it in your stomach' … sometimes they swallow it with that and everything … imagine how it gets in your stomach. *Banana worker, interview.*

Some workers and supervisors mentioned the relation of these substances with kidney damage. Health staff mentioned that workers are more interested in this potential damage due to the high prevalence of CKD in the area:

> [About tramadol] I tell them that consumption is not good because they can become addicted, or their kidneys might suffer. When you talk about the kidneys, they are more focused, they pay attention, because they know it is the one [disease] that is being treated the most and because you [Médecins sans Frontières] have come to give talks, and they are more interested in these topics. *Worksite health staff, interview.*

Some mentioned addiction to medications as a risk. This is particularly mentioned when medication use is not related to work: "*I know a lot of people that even on Sundays need to be taking* [medications] *and not for work, they just need to consume that to be in peace, that's an excess and addiction*" (Sugarcane worker, interview).

Workers mentioned the main adverse effect of the overuse of medications and energy drinks is *pasón*, as it is commonly known and is described as body cramps, convulsions, seizures, or overdose due to excessive use of medications: "*People have taken too much of it* [medications and energy drinks], *and they've collapsed, they've had seizures, tachycardia, so they've come to the clinic with quite a few problems from consuming too much*" (Worksite supervisor, interview).

To manage the perceived risks, participants mentioned some strategies. Some participants reported that strenuous physical activity helps "burn off" excess PNS in the body to metabolize them and prevent potential damage:

> You must *burn* the pill, if you take it and do not *burn* it, the pill knocks you out, it happened to me. I took a tramadol at seven in the morning after breakfast, and I started to work and at 11. I chewed the other one, but I did not burn it the same … I started to feel weak, dizzy, everything went dark, I did not see anything, and I went under a shadow, it was hard to get over that ailment, it was all dark and I felt it [the symptoms] for having taken them. *Sugarcane worker, interview.*

To respond to adverse effects, participants mentioned sniffing a cotton swab with isopropyl alcohol, ingesting lemon juice or allowing natural recovery of the person, although some have mentioned deaths related to *pasones* or to the overall use of medications:

> For me, I was able to control it [the use of medications and energy drinks]. Several colleagues have died, because of those drinks and the pills, some have died and some look really bad because of it. In my case, what helped me was that I went to the United States and I stopped [drinking] those beverages, then I went to the Capital [in Guatemala] and I stopped drinking it. I think that if I hadn't moved from here, I would be here or with my little [dialysis] bag. *Sugarcane worker, interview.*

Even when there are healthcare services within plantations some prefer not to inform the staff about the adverse effects, due to the prohibition of selling and using medications and energy drinks and their fear of being fired:

> Someone screamed and he [a worker] fell. The supervisors told me, "this guy took too many pills", they began to revive him and thank God he reacted. Then they told him: "We're going to take you to the clinic", "No, he said, because if I go to the clinic they'll suspend me [from work]". *Worksite supervisor, interview.*

Although some actors mentioned the direct relation of their use of medications and drinks to the demands for overproduction and overall work dynamics, there is a shared perspective that this is an individual decision: "*each person is responsible for*

consumption" (worksite health staff, interview). This perspective directly shapes how health risks are perceived, as participants frame potential physical harm as a consequence of personal choices rather than as an occupational hazard inherent to their work environment.

Discussion

Guatemala's agricultural systems, characterized by seasonality, piecework-based payment, and lack of protection for workers, contribute to the widespread use of medications and energy drinks among workers. Understanding this practice requires reflection on the intersections of poverty, substance misuse, social sanction and economic rewards.

Although the relationship between NSAIDs, other medications, energy drinks, and CKDnT is still unknown, research into this practice is a high priority.[17] This study contributes to documenting the social dimensions of this practice. We found a variety of substances used beyond PNS, including tramadol, which is potentially harmful when overused. Ultimately, our findings reveal that the use of medications and energy drinks functions as a coping mechanism to manage pain and increase working potential among agricultural workers.

Tramadol, used for pain control when NSAIDs are insufficient, is the only opioid that is not under international drug control, and it has been evaluated with low abuse potential.[47] Some authors have noticed that tramadol overuse might be an increasing trend among young persons.[48,49] Its use has been documented in other contexts among agricultural and other workers to enhance work ability.[27,33] Self-medication practices and the use of veterinary medications among Guatemalan workers in the U.S. have also been documented.[50] In Colombia, a Latin American country that shares some sociocultural characteristics with Guatemala, an increase in opioid sales, including tramadol, has been documented in recent years.[32] As Alhassan[28] mentions, the rise in tramadol consumption is in part a response to economic challenges, mainly seen in systems based on exploitation, and especially in low-income countries, such as Guatemala. Misuse or abuse of painkillers, like tramadol, can also be understood as a way to manage existential pain related to structural causes,[28,30] functioning as a buffer against the psychological toll of inescapable poverty, precarious labor conditions and the chronic stress of providing resources for their families. These factors are especially key when understanding the lived experiences of agricultural workers in Guatemala, who are subjects of a historical process of inequity, and impoverishment that contributes to the poverty cycle.[51]

Non-prescribed medication use has been documented in Guatemala by other authors.[34,52] Regulations that do not require the presence of pharmaceutical staff in pharmacies[52] might explain the extent of this practice. Our study documented widespread availability and easy access to medications and energy drinks – whether purchased over-the-counter in pharmacies and stores or through informal vendors (such as *chamorreros*, supervisors or other workers) – strongly facilitate their daily use. Moreover, *Raptor's* availability, large size, and low cost allow for daily use, increasing health risks.

Although some health risks and adverse effects mentioned by participants might not be medically accurate, addiction, seizures, and overdose can all be related to the overuse of tramadol and combinations with other PNS. Tramadol abuse can lead to health problems such as seizures,[47] especially after prolonged use.[53] Tramadol is not considered a nephrotoxic substance; however, its overuse might have an impact on the health of workers and may increase the risk of developing CKDnT, especially when consumed with other substances, such as energy drinks.

Adverse effects related to the constant consumption of energy drinks include increased blood pressure and heart rate[54] as well as acute kidney injury and other potential damage.[55] Marketing strategies focused on the increased energy for work these products can provide also contribute to widespread use.[55] In Guatemala, there is no law regulating the availability of energy drinks, the sale of the product to minors, or the provision of information to consumers regarding the potential risks of consumption.

In Guatemala, there is a legal minimal wage for agricultural work (around 377 USD or Q2,992 monthly)[56]; however, it is considered the worst paid labor category in the country, with pay ranging from 180 to 197 USD monthly (Q1,430 to Q1,563).[2,57] Piecework-based payment intensifies and increases workflow,[58] and production goals are usually set unilaterally by plantation owners.[59] These working systems are considered one of the key factors contributing to the use of medications and other substances.[34,60]

Some authors have documented the calorie and hydration levels needed by the body to sustain agricultural work is similar to those of high-performance athletes.[61] However, in Guatemala, many agricultural workers face poverty,[62] food insecurity, or limited access to nutritious meals during long work shifts.[63,64] Although our participants did not mention having experienced food insecurity, the need for performance enhancers, such as medications and energy drinks, may be a response to the precarious living conditions agricultural workers face.

The lack of compliance with the minimum wage is related to an overall lack of labor protection rights faced by agricultural workers in Guatemala. This adds to inadequate labor conditions and insurance coverage.[5,60,61,65] Theseconditions further exacerbate health risks for agricultural workers and compromise their health,[66] increasing their risk for CKD and CKDnT. Other structural factors that might contribute to the high prevalence of these diseases are the lack of compliance with pesticide use regulations[7] and the lack of health protection for workers.[37–41] However, our findings reveal a tendency among participants to individualize the use of substances and their associated risks. This alignment with personal responsibility narratives masks the structural labor demands of the agroindustry, shifting the responsibility for health outcomes away from structural working conditions and occupational hazards, framing the physical risks of substance use as a matter of personal choice rather than a systemic consequence of labor demands.

Improving working conditions and enforcing labor regulations, including adjustments to the piecework-based payment system and not incentivizing extreme production rates, are crucial to reduce occupational risks for CKDnT.[67] Policy changes must mandate structural adjustments to the piecework-based payment system, removing the economic incentives for extreme, health-compromising production rates. Specifically, regulatory frameworks must enforce mandatory paid rest and hydration breaks, alongside corporate accountability mechanisms that guarantee fair wages to reduce the dependence on the piecework-pay system. Furthermore, there is an urgent need for strict regulation of informal sales within and around plantations to curb the unregulated availability of medications.

For health promotion, interventions must move away from traditional risk communication and instead leverage community-wide and culturally adapted strategies. Given the social spread of substance use documented in this study and published in other papers,[35] health messaging should include not only agricultural workers but rather the broader community to inform about the risks associated with overuse of medications and combining substances. Crucially, these interventions must employ a non-stigmatizing, harm reduction framework. To maximize effectiveness, health promotion should actively integrate local paradigms, engaging with community concepts to co-designing messages that inform not only about risks, but also offer alternatives for symptom management, heat-stress recovery and overall wellbeing. Finally, future research should prioritize multi-disciplinary, mixed-methods studies to investigate the effects of combining NSAIDs, tramadol, and energy drinks under conditions of extreme heat and dehydration. Moreover, future research must continue to examine the intersection of environmental, agroindustry, and socio-economic factors that increase the risk of CKDnT and other chronic diseases among agricultural workers in Guatemala.

Limitations of this study primarily relate to our reliance on self-reported data that might be subject to recall or social desirability bias, potentially leading to an underestimation or concealment of consumption habits. Furthermore, we utilized convenience sampling to recruit participants, which helped us ensure willingness to participate in the study. This strategy is key in a context such

as Guatemala, where agricultural workers might be reluctant to talk about working conditions due to fear of reprisals. Logistical constraints prevented us from conducting comprehensive member checking with all participants, limiting participant validation of our interpretations to those who attended specific feedback meetings. While the localized nature and scale of our sample mean statistical generalizability is neither claimed nor intended, the triangulation among different participants allows us to ensure consistency of findings. Rather than generalizability, our study offers conceptual transferability: the structural dynamics and narratives of risk individualization documented in our study can be transferred and applied to understand health risks in other agro-industrial contexts characterized by piecework payment systems, extreme heat strain and precarious labor protections.

Conclusion

Our study contributes to the literature in documenting how structural aspects of the agricultural system in Guatemala create and reinforce an environment that requires the use of medications and other PNS to cope with its demands. Results illustrate how economic and structural constraints directly influence workers' health behaviors, often to their detriment. Long working hours, extreme physical demands, and pressure to meet high output targets appear to normalize the use of medications and energy drinks for labor endurance rather than using them as an exception. Overall, testimonies show high productivity outputs supersede health concerns regarding the potential health risks participants mentioned. The extent of self-medication practices, including the use of potentially nephrotoxic medications, is a response to an overall lack of protection of workers, who are impoverished and face exploitative conditions. While sensitization through health promotion to reduce the extent of this practice is needed, pay systems and exploitative labor culture also must change to reduce the systematized harms among agricultural workers that have driven them to practice these risky behaviors.

Author contributions

CRediT: **Diana Gómez-López:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing; **Fernando Orozco:** Conceptualization, Data curation, Formal analysis, Methodology, Writing – review & editing; **Sandra Herrera:** Conceptualization, Formal analysis, Methodology, Writing – review & editing; **Melissa Esteban:** Data curation, Formal analysis, Writing – review & editing; **Sylvie Pouit:** Conceptualization, Project administration, Validation, Writing – review & editing; **Berta Sam-Colop:** Conceptualization, Writing – review & editing; **María Pedroza:** Conceptualization, Writing – review & editing; **Lindsay Salem-Bango:** Formal analysis, Writing – original draft, Writing – review & editing; **Marion Demailly:** Formal analysis, Writing – original draft, Writing – review & editing; **Reinaldo Ortuño:** Conceptualization, Validation, Writing – review & editing; **Iza Ciglenecki:** Conceptualization, Investigation, Methodology, Supervision, Validation, Writing – review & editing.

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Data availability statement

The data that support the findings of this study are available from the corresponding author, DSGL, upon reasonable request.

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