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GLYPHOSATE AND ENVIRONMENTAL JUSTICE: A DISTRIBUTIONAL ANALYSIS OF HARMS, REGULATORY FAILURE, AND ETHICAL OBLIGATION

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Abstract: *This paper evaluates, through an environmental justice perspective, the distribution of benefits and harms of the widely used herbicide glyphosate. It examines not only the toxic and carcinogenic risks of glyphosate, but also the populations who disproportionately bear these effects. Glyphosate is the world's most widely used herbicide and has been a major subject of regulatory controversy. The International Agency for Cancer Research (IARC) and the U.S. Environmental Protection Agency (EPA) have reached different conclusions regarding glyphosate's carcinogenicity, differences that appear to stem from the use of public peer-reviewed studies versus proprietary industry-supplied data. This calls into question the reliability of confidential industry evidence in regulatory decision-making. This paper argues that current regulatory frameworks fail to equitably protect vulnerable populations and instead externalize health risks onto marginalized communities. Glyphosate exposure is disproportionately associated with harm among migrant workers, racial minorities, children, and low-income populations, who often experience elevated exposure levels and reside in high-risk environments. An ethical framework grounded in respect for persons, beneficence, and justice is applied to argue that current regulatory practices fail to protect marginalized populations. By applying an environmental justice lens, this paper proposes two comprehensive practice guidelines, one for farmworkers and one for physicians serving agricultural populations, as structural remedies to these systemic failures.*

Keywords: *glyphosate; environmental justice; CKDu; Mesoamerican nephropathy; occupational health; pesticide regulation; farmworkers; Roundup; bioethics.*

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INTRODUCTION

Glyphosate (*N*-phosphonomethyl glycine) is a broad-spectrum, systemic, non-selective organophosphorus herbicide and the active ingredient in Monsanto's Roundup, first brought to market in 1974. Chemically, it functions by inhibiting the plant enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), a critical enzyme in the shikimate pathway responsible for the biosynthesis of the aromatic amino acids phenylalanine, tryptophan, and tyrosine. Because this metabolic pathway is absent in mammals, glyphosate was initially considered to pose minimal risk to human health. Glyphosate's herbicidal action is non-selective, meaning it is toxic to virtually all plant species it contacts through foliage—and it kills only actively growing plants, making it ineffective as a pre-emergence herbicide.

Glyphosate's agricultural dominance expanded dramatically beginning in 1996 with the commercial introduction of genetically engineered 'Roundup Ready' crops. These included varieties of soybeans, corn, cotton, canola, and sugar beets engineered to carry a glyphosate-resistant EPSPS gene derived from *Agrobacterium* bacteria. This innovation allowed farmers to apply glyphosate post-emergence, killing weeds while sparing crops. By 2023, approximately 91% of U.S. corn, 95% of soybeans, and 94% of cotton were produced from strains genetically modified for glyphosate tolerance (Soares et al. 2021). Beyond row crops, glyphosate is used extensively for bare-ground weed control and as a pre-harvest desiccant. As a desiccant it acts as a ripening agent applied to dry crops uniformly before harvest, a practice that results in direct food residue exposure. Its primary metabolic breakdown product is aminomethylphosphonic acid (AMPA), which acts as a chelating agent binding to critical metal ions. In humans, glyphosate binds to serum albumin, bypassing the liver's detoxification system, and once inside the body, glyphosate and its metabolites disrupt critical cellular processes (Galli et al. 2024).

Glyphosate was introduced as a safer alternative to its predecessors, 2,4-D and 2,4,5-T; however, decades of evidence have revealed serious ongoing scientific debate regarding potential risks. In 2015, the International Agency for Research on Cancer (IARC) classified glyphosate as "probably carcinogenic to humans," while the European Food Safety Authority (EFSA) concluded it is unlikely to pose a carcinogenic risk under expected exposure conditions (International Agency for Research on Cancer [IARC] 2015; European Food Safety Authority [EFSA] 2015). IARC relies solely on publicly available, peer-reviewed studies, while EFSA incorporates proprietary industry-supplied data unavailable to independent researchers. These differing evidentiary bases have likely contributed to the contrasting conclusions. The real-world consequences of this regulatory uncertainty fall most heavily on those who work in close proximity to glyphosate. A dynamic clearly illustrated by the epidemic of chronic kidney disease of unknown origin (CKDu) among Nicaraguan sugarcane workers (Clark et al. 2016), which highlights a broader systemic failure to protect marginalized populations.

Through an environmental justice framework grounded in the principles of respect for persons, beneficence, and justice, this paper argues that current regulatory and agricultural practices create a burden carried predominantly by the most vulnerable populations. Proprietary data, corporate influence, and unsafe working conditions have produced a system in which economic gains are maximized while health risks are absorbed by farmworkers and marginalized communities. Structural reform in regulation, labor protections, and physician practice guidelines is not only a public health imperative but an ethical requirement.

REGULATORY CONTROVERSY

IARC and the EFSA reach divergent conclusions on glyphosate because they operate under different institutional mandates and apply different logics to scientific evidence and uncertainty. IARC's mission is cancer research and prevention (World Health Organization [WHO] 2019); accordingly, it focuses on identifying whether a substance is capable of causing cancer, prioritizing precaution, transparency, and protection of populations with potentially high or chronic exposure, such as agricultural workers. EFSA, by contrast, is tasked with risk management—assessing whether glyphosate poses an unacceptable risk under assumed real-world average exposure levels, regulatory

thresholds, and feasibility of control measures (EFSA 2015). IARC treats scientific uncertainty as a reason to signal potential harm; EFSA treats uncertainty as insufficient grounds for restriction. In March 2015, IARC classified glyphosate as "probably carcinogenic to humans" (WHO 2019), while EFSA concluded it is unlikely to pose a carcinogenic hazard (EFSA 2015).

Proprietary industry data play an important but imbalanced role in these assessments. IARC excludes unpublished studies and relies on publicly available, peer-reviewed literature to ensure transparency, independence, and reproducibility (WHO 2019). EFSA, by contrast, depends heavily on proprietary toxicological studies submitted by industry applicants as part of regulatory approval processes. Studies that are protected as confidential business information and inaccessible to independent researchers (EFSA 2015). Although these studies meet regulatory testing guidelines, their limited availability reduces opportunities for independent review and scientific scrutiny. This imbalance mirrors the tobacco industry's historical pattern, in which manufacturers controlled internal research and regulators depended on industry-submitted evidence while independent researchers lacked access to raw data—delaying regulatory action as evidence of harm grew. The result in both cases is a power imbalance that shapes not only how scientific evidence is interpreted but also whose knowledge is viewed as credible in public health decision-making (Portier et al. 2016).

The legal and corporate history of glyphosate further illustrates this imbalance. Monsanto, which developed Roundup beginning in 1974, was acquired by Bayer AG in 2018 for approximately $63 billion. The acquisition transferred an enormous litigation crisis: tens of thousands of plaintiffs alleged that long-term Roundup exposure caused non-Hodgkin's lymphoma. The first major trial in 2018 established that Monsanto had known of glyphosate's potential carcinogenicity and failed to warn consumers. Subsequent verdicts escalated substantially: in January 2024, a Pennsylvania jury awarded $2.25 billion to a man who developed non-Hodgkin's lymphoma after nearly 20 years of Roundup use; in October 2024, a Pennsylvania jury awarded $78 million in a separate case; and in April 2025, a Georgia jury ordered Bayer to pay over $2 billion. Bayer has paid over $10 billion in Roundup settlements to date and in February 2026 proposed a $7.25 billion global settlement to resolve current and future claims, with approximately 4,400 active lawsuits remaining in federal multidistrict litigation. Following shortly after was an executive order signed by United States President Donald Trump, invoking the Defense Production Act to prioritize domestic glyphosate production. While Bayer ceased selling residential glyphosate formulations in the United States in 2023, commercial agricultural formulations remain widely available. The EPA declined to conduct a new safety review following an environmental group's 2024 request (Frazin 2025).

Controversy surrounding the question of whether Bayer can be sued under state law for a failure to warn about cancer risks has now reached the Supreme Court. At the center of the argument is the idea of federal preemption—that is, do federal laws take precedence over conflicting state laws? Bayer argues that the EPA's approval of glyphosate labels should override state laws. However, the plaintiffs believe that federal regulatory approval does not account for long-term or high-exposure risks. The center of this argument is John Durnell, a gardener who worked with Roundup for decades and was diagnosed with non-Hodgkin lymphoma. If the Supreme Court agrees with Bayer, many of the cases suing Roundup will become null and void. This case does more than highlight the scientific uncertainty regarding glyphosate.

Monsanto Co. v. Durnell (2026) illustrates that scientific uncertainty is being reshaped in the courts. The outcome of this case could establish a new precedent for future cases about chemical exposure where state laws conflict with federal regulations. These legal proceedings demonstrate that the corporate handling of glyphosate safety information followed patterns long documented in industries that externalize health risks onto the most exposed and least protected populations.

The IARC–EFSA divergence carries significant environmental justice implications. IARC's hazard-based approach is oriented toward populations at the highest risk, those with intensive and long-term exposure, and treats scientific uncertainty as a basis for precautionary action. EFSA's risk-based framework, by contrast, is calibrated to average population exposure and assumed conditions of safe use. This framing systematically misrepresents the

actual exposure reality of agricultural and migrant workers, who encounter glyphosate repeatedly in occupational settings, often lack access to adequate protective equipment, and face structural barriers to healthcare access and meaningful participation in regulatory processes (Castillo et al. 2021). When regulatory safety thresholds are set using industry-backed data calibrated to average consumers rather than the most exposed workers, the resulting health risks to farmworkers are implicitly deemed acceptable. This effectively transfers the burden of scientific uncertainty onto those communities least equipped to bear it, compounding pre-existing health inequalities. The disagreement between IARC and EFSA is therefore not merely a technical dispute, but it reflects a deeper question of whose health and whose evidence are centered in environmental health policy (Portier et al. 2016).

DISTRIBUTION OF EXPOSURE AND HEALTH INEQUITY

An environmental justice framework emphasizes that environmental health risks are shaped not only by exposure pathways but also by the social, economic, and political structures that determine who benefits from industrial practices and who bears their costs. In the case of glyphosate, the benefits of its use are largely concentrated among agribusiness corporations, large-scale agricultural producers, and consumers who are geographically and socially removed from sites of application, while the harms disproportionately affect marginalized communities with limited capacity to influence regulatory and policy decisions (Mengistie et al. 2025).

Glyphosate is valued for its effectiveness, low cost, and compatibility with genetically modified herbicide-tolerant crops, making it central to industrial agricultural systems. Its use enables high-yield monocropping, reduces labor demands, and supports large-scale farming practices that prioritize efficiency and profitability (Soares et al. 2021; Galli et al. 2024). These benefits contribute to relatively stable food supplies and lower consumer food prices, particularly in high-income countries. Corporations that manufacture glyphosate-based products and glyphosate-resistant seeds have accrued significant economic gains, reinforcing market dependence on chemical weed control and shaping agricultural norms and policies (Frazin 2025). However, these benefits are unevenly distributed and largely detached from the environmental and health risks associated with glyphosate exposure.

In contrast, the harms linked to glyphosate use are concentrated among populations that experience frequent, cumulative, and often involuntary exposure. Agricultural workers—particularly migrant, undocumented, and seasonal farmworkers—are among the most heavily exposed due to occupational handling of herbicides, proximity to treated fields, pesticide drift, and contaminated water sources (Castillo et al. 2021). In the United States, Latino and immigrant farmworker communities face compounded vulnerabilities stemming from economic insecurity, limited access to healthcare, language barriers, and fear of retaliation or deportation, which may discourage reporting of unsafe working conditions or health concerns.

Scientific evidence increasingly associates glyphosate exposure with adverse health outcomes that raise serious equity concerns. Epidemiological and biomonitoring studies have linked glyphosate and its primary metabolite AMPA to liver inflammation, metabolic syndrome, and other metabolic health risks in young adulthood (Eskenazi et al. 2023; Otaru et al. 2024). Additional research suggests associations with kidney disease, particularly among agricultural laborers in regions with intensive chemical use and limited workplace protections (Clark et al. 2016). Mechanistic and experimental studies further indicate that glyphosate disrupts mitochondrial function, alters oxidative stress pathways, and damages cellular energy production, which may contribute to long-term systemic health effects (Strilbyska et al. 2022). Emerging evidence also highlights potential neurological impacts: glyphosate can alter gut microbiome composition and disrupt the gut–brain axis, with implications for immune regulation and neurological health (Barnett et al. 2022; Walsh et al. 2023). Animal studies indicate that glyphosate exposure may exacerbate neuroinflammation and neurodegenerative pathology even after prolonged recovery periods (Bartholomew et al. 2024).

Children represent an especially vulnerable population within this environmental justice context. Studies demonstrate that children consuming conventional diets exhibit significantly higher levels of pesticide metabolites

than those consuming organic diets, and that organic diet interventions can rapidly reduce exposure (Bradman et al. 2015). This disparity underscores how socioeconomic status shapes the ability to avoid environmental hazards, as organic foods and safer housing options remain inaccessible to low-income families.

Environmental justice scholarship emphasizes that disproportionate exposure is inseparable from issues of power and participation. Marginalized communities are not only more exposed to glyphosate but also less involved in the regulatory and decision-making processes that govern pesticide approval, use, and safety standards. Reviews focused on Black, Indigenous, and People of Color (BIPOC) and Indigenous communities in the United States highlight that pesticide exposure compounds existing environmental and health inequities rooted in structural racism, labor exploitation, and historical marginalization (Mengistie et al. 2025). These communities often lack meaningful representation in policy forums, risk assessment processes, and agricultural decision-making, despite bearing the greatest health burdens. Taken together, the evidence demonstrates that glyphosate use in modern agriculture embodies a deeply unequal distribution of benefits and harms requiring structural changes in agricultural policy, labor protections, and regulatory frameworks that center the rights, voices, and health of communities most affected by chemical exposure.

CASE STUDY: NICARAGUAN SUGARCANE WORKERS AND CKDU

Chronic Kidney Disease of unknown origin (CKDu), also called Mesoamerican nephropathy, is a "silent killer" that has reached epidemic proportions among agricultural workers in Nicaragua, particularly those in sugarcane fields. Unlike conventional chronic kidney disease, CKDu is not linked to diabetes or hypertension; it affects young, otherwise healthy men, develops without obvious early warning signs, and by the time symptoms are severe enough to prompt medical attention, the damage is often irreversible (Clark et al. 2016). CKDu has killed over 20,000 workers along the Pacific coast of Central America over the past two decades and has become the leading cause of death among sugarcane workers in the region (Keogh et al. 2022).

The causal picture of CKDu is not reducible to heat and dehydration alone, but it is a multifactorial disease in which glyphosate plays a distinct and mechanistically plausible role. The kidney's proximal tubules are uniquely sensitive to both ischemic and nephrotoxic injury. In sugarcane workers, repeated cycles of dehydration and heat stress reduce renal perfusion, triggering subclinical episodes of acute kidney injury that initiate inflammation, oxidative stress, and progressive tubular scarring. Glyphosate compounds this injury through a specific mechanism: as a small, water-soluble molecule capable of entering the body via ingestion, inhalation, and dermal absorption, it binds heavy metals such as cadmium and arsenic, forming stable glyphosate-metal complexes with a half-life estimated at over 20 years (Clark et al. 2016; Sarich 2014). These complexes accumulate in renal tubular tissue, where they directly interfere with cellular energy metabolism, increase reactive oxygen species production, and damage the tubular epithelium in ways that pure heat exposure cannot explain.

This nephrotoxic mechanism is further supported by glyphosate's ability to bypass hepatic detoxification, binding to serum albumin and evading first-pass liver metabolism, allowing it to reach the kidney in biologically active concentrations not predicted by standard toxicological models (Galli et al. 2024). Research also implicates glyphosate-induced disruption of mitochondrial function and oxidative phosphorylation in proximal tubular cells, consistent with the patterns of tubular atrophy and interstitial fibrosis seen in CKDu histology (Strilbyska et al. 2022; Clark et al. 2016).

Additional co-factors intensify this toxic burden. Workers frequently self-administer nonsteroidal anti-inflammatory drugs (NSAIDs) for musculoskeletal pain, which independently reduce renal prostaglandin synthesis and worsen dehydration-related ischemia. Company physicians and pharmacists in Nicaragua are also prescribing diuretics, antibiotics, and NSAIDs to workers experiencing symptoms likely related to volume depletion—medications that may function as additional contributors to kidney damage rather than treatment (Ramirez-Rubio et al. 2013). Contaminated water sources introduce further nephrotoxins, including arsenic that, when chelated by glyphosate, may become more bioavailable to kidney tissue. There is clear evidence spanning five decades that

pesticide use in Nicaragua, especially glyphosate, is causing both acute and chronic effects at a high incidence rate in the agricultural population (Corriols 2010). The convergence of chemical nephrotoxicity, heat-related ischemia, pharmacological insult, and nutritional inadequacy creates a cumulative burden that explains why CKDu progresses with such severity in this population.

The environmental justice dimensions of this case are stark. The workers most affected are among the most economically marginalized: seasonal laborers who must earn an annual income in six months, with no viable alternative employment. Dialysis and kidney transplant, the only effective treatments for end-stage CKDu, are financially inaccessible to virtually all affected workers. The geographic concentration of CKDu in sugar-producing communities, its restriction to occupationally exposed workers, and its disproportionate impact on young men of working age all reflect a pattern of structurally produced vulnerability that cannot be explained by individual biological susceptibility alone (Clark et al. 2016). The demand for sugar worldwide is increasing, which will cause further unmonitored expansion of the industry and broader exposure without intervention. The persistence of the epidemic despite years of awareness reflects systemic failures of regulatory oversight, corporate accountability, and occupational health protection.

ETHICAL ANALYSIS

The glyphosate crisis among agricultural workers is an ethical failure of the first order, implicating the principles of respect for persons, beneficence and nonmaleficence, and justice as they apply to chemical regulation, occupational health, and the physician's role in communities shaped by structural inequality. Ethically, allowing profits from an industry to increase at the expense of the lives of the poorest and most vulnerable members of society violates every foundational principle of ethics. It will be argued that according to the ethical principles of respect for persons, beneficence/nonmaleficence, and justice, action must be taken immediately to address the concerns surrounding glyphosate and the cause of CKDu. Such actions will not only save lives but will also do much to restore the trust that has been lost among the most vulnerable populations.

Respect for Persons

"Respect for persons" refers to the right of a person to exercise self-determination and to be treated with dignity and respect. The principle divides into two separate moral requirements: the requirement to acknowledge autonomy, and the requirement to protect those with diminished autonomy (National Commission for the Protection of Human Subjects 1979). Numerous abuses of farmworkers, especially sugarcane workers in Nicaragua, have been documented, including long working days and weeks, inhumane working conditions, inadequate protection from pesticides, and unjust salaries. Many of these workers are hired only during the harvest season and must earn their living for an entire year in just six months' time. These abuses should be abhorrent to anyone. But for medical personnel who care for these workers in the camps, these abuses should have been reported and stopped. To witness or to have known about any of these abuses and not to have reported or attempted to stop them is a direct violation of the principle of respect for persons. Every ethical document from the Hippocratic Oath to the UN Universal Declaration of Human Rights clearly states that "no human person should be subjected to torture or to cruel, inhumane or degrading treatment or punishment" (United Nations 1948).

To highlight the point that these workers are not being treated with dignity and respect: sugarcane companies are under pressure to minimize growing and processing time in order to increase output. The chemicals used to increase output are having serious medical consequences for workers, including acute kidney injury. In addition, the burning of fields at the end of the growing season leaves a scorched earth, killing native plants and causing harm to children, pregnant women, and livestock. During the harvest season, temperatures are extremely high and there is no trace of water or shade available to the workers; even prescribed rest periods appear to be non-

existent. Company medical personnel are allegedly aware of these conditions and treat workers for dehydration, kidney injury, urinary tract infections, and heat stroke, but then send them back into the fields. Failing to report such conditions as cruel, inhumane, and degrading treatment defies comprehension medically, legally, ethically, and from a humanitarian perspective.

Farmworkers are truly vulnerable persons with diminished autonomy who deserve added protection. They are at the mercy of their employers and have limited governmental protections. The physician-patient relationship is the primary focus of ethics in medicine: trust is its foundation, and the burden is on the physician not only to receive the patient's trust but to build a solid foundation upon which that trust can rest (Purtilo 1995). If this relationship becomes fractured, a loss of confidence will result, and the effect on the patient could be devastating. For farmworkers to observe their primary care physicians—or physicians supplied by agricultural companies—providing inadequate medical care or remaining silent in the face of human rights violations undermines the credibility of the medical profession and is irreconcilable with the physician's role as healer. There is a definite conflict or "dual loyalty" between the physician's duty to the patient and the medical professional's duty to the employer. Participation in blatant breaches of patient autonomy not only violates the fiduciary physician-patient relationship but shows a clear conflict between serving the interests of the company and serving the interests of the patient. This violation may also prevent some workers from seeking needed medical care due to the loss of trust in their physician. A basic tenet of the principle of respect for persons is that one must never use another person as a means to an end; opponents argue that farmworkers are being used precisely as means to maximize outputs and achieve company quotas, making human rights and basic dignity the casualty.

The failure of company physicians, company executives, and governmental agencies to be proactive in addressing the medical needs of this most vulnerable population regarding glyphosate and CKDu is causing needless suffering and death. These workers have no choice but to work in the fields; it is a matter of survival. The cause of CKDu must be determined now, and new policies must be initiated to protect this vulnerable population. To deny farmworkers safe working conditions and proper medical care clearly violates the ethical principle of respect for persons.

Beneficence and Nonmaleficence

The principle of beneficence involves the obligation to prevent, remove, or minimize harm and risk to others and to promote and enhance their good. Beneficence includes nonmaleficence, which prohibits the infliction of harm, injury, or death upon others. In medical ethics, this principle has been closely associated with the maxim *primum non nocere* ("Above all, do no harm"). Farmworkers have the right to know about glyphosate and its effects on the kidneys and other organs. Family members and sugarcane workers argue that the government of Nicaragua is corrupt and in collusion with private industry to promote profit. The government argues that it is doing everything possible to promote and enhance the good of the sugarcane workers. The problem is that this is a contradiction—the cause of CKDu still remains inadequately addressed.

Governments and large farms argue they have instituted new policies to keep workers safe and alive. Industry executives stipulate that mobile clinics equipped with a cooling area take blood and urine samples and offer hydrating beverages and food for workers in the fields, and that they pay workers for a seventh day of rest. Opponents argue that there are not enough medical supplies and hydration packets for the number of workers in the fields, that the mobile clinics screen only workers who are not sick, and that more provisions appear only when visitors are present (Wei 2015). Even if the intentions of the government and the farming industry are good, the unjust working conditions and use of pesticides in the fields constitute a violation of nonmaleficence.

There is clear evidence from studies over the past 50 years of a negative impact of pesticide use. Glyphosate attacks the kidney tubule, binding to heavy metals to form compounds that persist in the body for over 20 years, thus the word "chronic" in the disease name. Because glyphosate can be inhaled, ingested, or absorbed

through the skin, farmers and sugarcane workers are especially at risk. Furthermore, the human liver cannot detect glyphosate, so it bypasses hepatic purification and goes directly to the kidney tubules, where glyphosate-metal complexes cause severe damage (Sarich 2014). In addition, due to poor working conditions and frequent dehydration, company physicians and pharmacists are prescribing diuretics, antibiotics, and NSAIDs for symptoms related to dehydration and volume depletion. These factors, alone or in combination, may be possible contributors to kidney damage, and researchers highly recommend that acute kidney damage coupled with volume depletion and medication exposures be further evaluated as causal factors for CKDu (Ramirez-Rubio et al. 2013). Twenty thousand innocent lives have been lost and more will die unless we maximize benefits and minimize harms. This can only be done by funding further research, instituting government regulations on working conditions, and banning glyphosate use in the sugarcane fields. Failure to recognize this need is a failure not only of beneficence but also of nonmaleficence.

At the corporate level, Bayer and Monsanto's decades-long litigation record demonstrates a pattern of prioritizing market access over transparent harm disclosure. The internal suppression of safety data directly caused preventable harm to hundreds of thousands who were denied the information needed to assess their own risk (Frazin 2025). The $10 billion already paid in Roundup cancer settlements represents the quantified externalization of human suffering onto workers, farmers, and consumers who were never given the opportunity to provide informed consent to that risk.

Justice

The principle of justice recognizes that each person should be treated fairly and equitably and be given his or her due. The principle of justice can be applied to the circumstances of "dual loyalty" when sugar company physicians must choose between responsibility for their patients and the demands placed upon them by industry executives. The most common rationale for medical professionals' willingness to participate in or overlook incidents of abuse is their sense of duty to their employer. When company physicians treat sugarcane workers for symptoms of CKDu, many believe they are acting in the best interests of the workers, the nation, and humanity. However, they are at times ignoring symptoms, sending workers back into the fields to further damage their kidneys. Despite knowing full well that none of these workers could ever afford dialysis. Is this treating someone fairly and equitably?

These physicians must know that CKDu is an epidemic. They must know its symptoms. They must know that the working conditions are unjust and harmful. They must know, or at least suspect, that glyphosate is a major contributing factor. They must also suspect that the medications they are prescribing will not help these workers in the long run. Every medical professional has the right, with a well-formed conscience, to refuse any order believed to be unjustified and personally unethical. Every medical professional has the duty to report conditions believed to contribute to this epidemic. The failure of medical professionals to recognize that their duty as a company employee can never trump medical ethical principles is clearly an injustice, not only to those abused but to humanity as a whole. If the principle of justice mandates that each person should be treated fairly and equitably, then participation of medical professionals in cruel, inhumane, and degrading treatment of workers clearly violates that principle.

We Americans espouse the belief that all men and women are created equal, a principle that has been foundational to the medical profession as well. If we truly believe in equality, we should insist that all men, women, and children receive equal medical treatment and resources. Denying knowledge of proper treatment to individuals suffering from CKDu, and treating workers only to return them to the fields where they will be further compromised, violates a basic tenet of justice. It is the responsibility of all wealthy nations and international developmental agencies to solve this medical mystery, not only because it is in the best interest of Nicaraguan sugarcane workers, but because Central America exports large amounts of raw sugar to developed nations. The raw sugar, because of pesticide use, could have adverse effects on others as well. Failure to find the causes of CKDu is ethically

irresponsible and morally objectionable. To compromise the basic ethical foundations upon which medicine stands is destructive not just for the sugarcane workers of Nicaragua but for humanity as a whole.

The environmental justice framework within which this paper operates extends the principle of justice beyond individual clinical interactions to the structural distribution of risk, benefit, voice, and power across populations. Agricultural workers bear the greatest glyphosate exposure, have the least access to regulatory processes governing those exposures, receive the fewest economic benefits from the systems generating their risk, and are systematically excluded from the scientific knowledge that would allow them to understand and contest their situation (Mengistie et al. 2025). Justice requires wealthy nations and international development institutions to acknowledge their role in sustaining the agricultural systems that generate this inequity and to contribute materially to the research, regulatory reform, and occupational health infrastructure needed to address it.

Taken together, the three ethical principles converge on a single conclusion: the current treatment of glyphosate-exposed farmworkers, and the regulatory and corporate systems that sustain it, fail every foundational standard of medical and public health ethics. Reform is not merely desirable; it is an ethical imperative.

RECOMMENDATIONS

Unless the world community addresses the need for additional education and proposes new policies, the goal of eradicating CKDu will remain out of reach. The ethical analysis of this paper makes clear that isolated policy adjustments are insufficient to address the structural harms imposed on glyphosate-exposed agricultural workers. What is needed are institutionalized, evidence-based standards that operationalize ethical obligations in the two settings where they matter most: the fields where workers are exposed, and the clinical encounters where physicians are tasked with their care. This paper proposes two comprehensive guidelines.

Guideline 1: Farmworker Occupational Protection Standard for Glyphosate-Exposed Agricultural Laborers

This guideline is designed to be adopted at the farm, cooperative, and national regulatory level, grounded in the ethical obligation to provide truly informed, freely given consent to occupational chemical exposure. A condition that requires both information and the genuine capacity to act on it.

1.1 Informed Consent and Chemical Transparency

Prior to employment and annually thereafter, all workers must receive comprehensive, linguistically and culturally accessible disclosure of the chemicals used in their workplace, with specific emphasis on glyphosate: its mechanism of action, documented health risks including nephrotoxicity and carcinogenicity, biomonitoring evidence from peer-reviewed literature, routes of entry into the body, and the regulatory disagreements between IARC and EFSA (Portier et al. 2016). This information must be provided in workers' native languages using visual formats accessible to those with limited literacy. Workers must have the genuine ability to refuse high-exposure tasks without economic retaliation. A protection requiring enforceable whistleblower protections and access to independent legal counsel.

1.2 Standardized Work Hours, Environmental Conditions, and Hydration Protocols

Given the established synergy between heat stress, dehydration, and glyphosate-mediated nephrotoxicity in the development of CKDu (Clark et al. 2016), work hour limitations and environmental protections are not merely labor rights but medical necessities. Employers must enforce maximum daily working hours in accordance with ambient temperature and heat index thresholds, with mandatory shade breaks of no less than 15 minutes per hour when temperatures exceed 32°C (90°F). Hydration must be provided freely and continuously, with minimum water intake targets prescribed on the basis of ambient conditions. These protocols must be monitored by an independent occupational health officer with no financial relationship to the employing company.

1.3 Personal Protective Equipment Standards and Age Restrictions

All workers handling or in proximity to glyphosate application must be provided with chemically resistant gloves, protective eyewear, respiratory protection rated for organophosphate aerosols, and appropriate full-body coverage, provided at no cost to the worker. No workers under the age of 18 may be employed in roles with direct glyphosate exposure. Workers who are pregnant, immunocompromised, or have documented kidney disease must be assigned to non-exposure roles with equivalent compensation. These requirements should be embedded in national agricultural labor codes with penalties for noncompliance proportionate to company revenue.

1.4 Mandatory Occupational Health Monitoring and Early Detection Screening

All glyphosate-exposed agricultural workers must receive a comprehensive baseline health evaluation prior to employment, including kidney function testing (serum creatinine, estimated glomerular filtration rate [eGFR], urinary protein-to-creatinine ratio) and biomonitoring for glyphosate and AMPA in urine (Eskenazi et al. 2023; Otaru et al. 2024). Repeat testing must occur at six-month intervals, with results communicated directly and confidentially to the worker through an independent clinical provider. Workers with progressive decline in kidney function or elevated urinary biomarkers of tubular injury must be removed from further exposure, referred to a nephrologist, and provided income replacement during the evaluation period.

Guideline 2: Clinical Practice Standard for Physicians Serving Glyphosate-Exposed Agricultural Populations

This guideline addresses the obligations of physicians—including primary care providers, occupational medicine specialists, and any clinician serving agricultural communities—in providing ethically grounded, environmentally informed care to glyphosate-exposed patients. It operationalizes the principle of patient-centered loyalty in contexts where physicians face institutional pressure to subordinate clinical judgment to corporate interests.

2.1 Environmental and Occupational History as Clinical Standard

Every clinical encounter with a patient employed in agriculture must include a structured environmental and occupational history documenting specific pesticides handled including glyphosate, years and frequency of exposure, personal protective equipment (PPE) use, proximity to treated fields, and access to clean water and sanitation at the worksite. This history must be documented in the medical record and updated annually. Physicians should recognize that patients may underreport exposure due to fear of job loss, distrust of authority, or lack of awareness that

exposure is clinically relevant. Rapport-building, trained medical interpreters, and integration of community health workers into the care team are clinical necessities in this population.

2.2 Clinical Baselines and Kidney Function Surveillance

Physicians must establish individualized renal function baselines for all agricultural patients and monitor these longitudinally, including annual measurement of serum creatinine, calculated eGFR, spot urine albumin-to-creatinine ratio, and urinalysis with microscopy. When CKDu is suspected—particularly in young male agricultural workers with non-diabetic, non-hypertensive kidney disease and progressive proteinuria—physicians should obtain urinary biomarkers of proximal tubular injury (beta-2 microglobulin, neutrophil gelatinase-associated lipocalin [NGAL], kidney injury molecule-1 [KIM-1]) and refer promptly to nephrology (Clark et al. 2016).

2.3 Pharmacological Caution and Harm Reduction Counseling

NSAIDs—commonly self-administered by agricultural workers for musculoskeletal pain—reduce renal prostaglandin synthesis and compromise autoregulation of renal perfusion under dehydration conditions, a dangerous interaction in patients with existing tubular injury (Clark et al. 2016; Ramirez-Rubio et al. 2013). Physicians must counsel strongly against routine NSAID use in this population, offer evidence-based alternatives for pain management, and document medication counseling in the chart. Diuretics and certain nephrotoxic antibiotics should be avoided when safer alternatives exist.

2.4 Gut-Microbiome and Neurological Awareness

Emerging evidence implicates glyphosate in disruption of the gut microbiome and, through the gut-brain axis, in neuroinflammation and neurodegenerative pathology (Barnett et al. 2022; Walsh et al. 2023; Bartholomew et al. 2024). Physicians serving agricultural populations should include inquiry about neurological symptoms—cognitive changes, mood disturbances, headaches, sensory changes—in the occupational health review and refer for neurological evaluation when glyphosate exposure may be a contributing factor.

2.5 Patient Advocacy and Institutional Loyalty

The physician's primary legal and ethical obligation is to the patient. No employment contract, corporate directive, or governmental instruction can override the physician's duty to provide an honest diagnosis, disclose occupational hazards, recommend removal from exposure when clinically indicated, and report conditions posing a threat to public health (Clark et al. 2016). The practice of treating workers for symptoms of occupational disease and returning them to the conditions producing those symptoms, without disclosure or advocacy, violates beneficence, nonmaleficence, and justice, and must cease.

CONCLUSION

The cumulative evidence demonstrates that the widespread use of glyphosate represents a critical environmental and ethical crisis defined by a structural imbalance of power and a disproportionate distribution of risk. While industrial farming systems benefit from high-yielding monocultures and financial gain, the health risks are borne predominantly by marginalized migrant workers. This situation is exacerbated by a regulatory system that favors proprietary industry studies over transparent, evidence-based science, systematically ignoring the lived experiences of those most frequently and involuntarily exposed (Portier et al. 2016). The legal record of Monsanto and Bayer—over $10 billion in cancer settlements and a proposed $7.25 billion global resolution—makes plain that the harms of glyphosate were known, concealed, and externalized onto people who were never given the information or the power to protect themselves (Frazin 2025). The CKDu epidemic in Nicaraguan sugarcane workers is not a medical anomaly; it is the predictable endpoint of a system that treats vulnerable human beings as acceptable costs of industrial food production (Clark et al. 2016).

The glyphosate crisis represents a critical failure of global governance—a failure to uphold the principles of justice and beneficence by prioritizing economic considerations over the fundamental right to a safe and healthy environment. The two guidelines proposed in this paper are not aspirational ideals; they are the minimum ethical requirements that flow from taking seriously the principles of respect for persons, beneficence, and justice as applied to the most exposed, most harmed, and least protected members of the global agricultural workforce. Unless the world community addresses these needs through additional education and new policy, we will never attain the goal of eradicating CKDu. Structural reform in regulation, labor protections, and medical practice is not optional: it is an ethical imperative.

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