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Algorithmic Exclusion of Informal and Migrant Construction Workers from Occupational Safety Governance in Türkiye

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Research Article

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Abstract

Digitalization is typically described as improvement of governance in the realm of occupational health and safety (OHS) because of the use of automated registers, up-to-date inspection data, and penalties that are triggered by algorithms. This paper questions that assumption by examining what happens to workers whom a digital system cannot register in the first place. Drawing on digital-divide theory, the concept of the system-level bureaucracy, and the digital-welfare-state critique, the paper introduces the Digital Shadow Labor (DSL) Framework: a four-gate model of Identity, Navigation, Data Visibility, and Accountability through which informal and migrant workers are filtered out of digital OHS governance before protection can reach them. The framework is applied to Türkiye's construction sector, where the state's e-Government-integrated (e-Devlet) OHS registration and monitoring system (İSG-KATİP), operates alongside a large informal and Syrian migrant workforce concentrated in exactly the trades with the highest fatality rates. Recent social-security-based governance data show that construction accounts for a disproportionate share of recorded occupational deaths relative to its share of registered employment; whether this concentration also understates the true toll among unregistered workers is, this paper argues, a plausible but not yet directly evidenced extension of that finding, and one the paper treats accordingly. According to the analysis, digital OHS infrastructure, without any design of inclusion, is in danger of turning a temporary deficit into a constitutive feature of the governance process, having implications for legality and democracy that go beyond the borders of Türkiye.

1. Introduction

Globally, OHS regulation has been computerized on the assumption that computerization solves the shortcomings of paper processes in the areas of uneven inspections, late penalties, and lack of transparency in record keeping. Computerized registries tie the legal obligations of employers to national identification systems, impose penalties automatically if an enterprise does not have an accredited safety expert, and provide statistics that help formulate policies at the national level. At face value, it is true that this initiative marks progress compared to the traditional inspection processes. However, a process designed to identify and take actions based on identified relationships is able to provide protection for recorded relationships only. For a worker who is not registered in the system, he/she is not just underserved, but is also invisible in the process, and the dangers that such worker faces every day go unnoticed too.

This research tackles the ignored issue head-on. This work examines the effects on OSH governance that arise from the fact that those at most risk of physical harm (workers who operate as informal or undocumented migrant workers in hazardous jobs) are simultaneously the most unable to access the digital network meant to safeguard them. There are two contrasting arguments that should be examined. First of all, digitalization can perpetuate the same problems that occurred during the previous paper-based enforcement period, where digitalization simply repeats the same inequalities that were in place before; here, digital OSH is neutral regarding informality, but incomplete. Alternatively, digitalization can actually enhance the boundary between formal and informal work, which becomes a technical barrier rather than an administrative one, with every round of enforcement making it even harder to enforce any OSH regulations. This is the claim I make in this work. Digitalization works in situations where formal registration is already in place, where it creates a distinction between the visible and the invisible worker, a distinction which is more pronounced and harder to observe than with manual enforcement (Bovens & Zouridis, 2002).

Turkish context appears as one of the rarest cases in which the issue is clearly evident. There are three factors in the case which are seldom found to exist in tandem: an entirely digitalized and e-Devlet-compliant OHS regulation system, a construction industry that makes use of both informal labor force in the country and that of Syrian refugees; and the fact of disproportional fatal OHS accidents among the same labor force in that particular industry. In the process of Syrian migration, there have been significant changes in the structure of Turkish informal labor markets, specifically in construction and agricultural sectors (Aksu et al., 2022). Against this backdrop, the state has pursued digital-first enforcement through İSG-KATİP, the national OHS registration and monitoring platform, without a parallel strategy for the workers that platform cannot see. The stakes are not abstract. Construction remains one of the most hazardous sectors in the Turkish economy, and the population least visible to its governing infrastructure is also, by the logic developed in this paper, the population least able to demonstrate the scale of the risk it faces.

The paper makes two contributions. First, it develops the Digital Shadow Labor Framework, a theoretical model that synthesizes digital-divide theory (van Dijk, 2005, 2020; Ragnedda, 2017) with the system-level bureaucracy thesis (Bovens & Zouridis, 2002) and the digital-welfare-state critique (Alston, 2019) into a sequence of four exclusion gates specific to safety governance rather than welfare distribution, the domain in which these theories were originally developed. Second, it applies the framework to the Turkish construction sector, connecting governance theory to a body of empirical OHS research on Syrian migrant and informal workers that has so far developed largely in isolation from digital-governance scholarship. This isolation is not a minor citation gap. Such an articulation implies that there is extensive academic knowledge available on how exclusion affects Turkish society in terms of OHS, but very little knowledge regarding what makes it possible, namely how the system of compliance works. Such an integration holds significance beyond the Turkish case because, broadly speaking, the vast majority of literature dedicated to OHS digitalization both in Turkey and elsewhere, assesses such systems in terms of their efficiency, i.e., the degree to which the platform decreases paper work, speeds up inspections, and reduces the costs of administration for the workforce involved in terms of the registered population. Although such an assessment is valid, it is still not comprehensive since it ignores the very boundary of registration as something that needs to be explained rather than assumed. The second section provides the necessary institutional and theoretical background that is needed to understand both aspects of the gap above. The third section provides the Digital Shadow Labor Framework. The fourth section applies the framework to the

case of Turkey. The fifth section discusses legal and democratic implications of the framework and the sixth section provides policy implications along with some limitations.

2. Background: Digital Governance and OHS Compliance in Türkiye

2.1 From Paper to Platform: İSG-KATİP and e-Devlet-Integrated OHS Enforcement

The İSG-KATİP (Occupational Health and Safety Record Keeping and Monitoring Program) is the system designed by the Ministry of Labor and Social Security of Turkey that registers, monitors, and controls the implementation of requirements concerning occupational safety. According to the system, it is necessary to appoint certified occupational health and safety (OHS) experts and doctors in the workplace. These appointments are made and confirmed on the e-Government (e-Devlet) website using the national identity numbers (TC Kimlik Numarası) of the appointed people. As soon as the requirement is registered, it is monitored automatically. When an appointment does not exist or expired, the system flags the issue, and penalties are applied according to the predetermined logic.

This is a clear example of the transformation from street-level to system-level bureaucracy identified by Bovens and Zouridis (2002). Under manual bureaucracy, the labor inspector would have used contextual discretion in the field when judging whether a newly introduced subcontractor had violated safety rules or whether the physical safety of the employee outweighed the status of his or her employment. However, under system-level bureaucracy, this discretion is transferred from the labor inspector to the designer of the software program, who designs the logic which is uniformly applied to all cases by the software. This, according to Bovens and Zouridis, results in real gains, such as increased consistency, speed, and decreased discretion or bias built into the system, but at the same time means that what is entered into the system in terms of its input is the final boundary for any form of protection.

2.2 The Informal and Migrant Construction Workforce: Scale and Vulnerability

The construction industry has always had a fair share of Turkey's domestic informal sector as well as the Syrians' labor force, as evidenced by various recent Turkish and foreign-language studies (Çınar, 2019; Öçal & Şenel, 2021; Aksu et al., 2022). Laborers from Syria working in construction usually lack permits to carry out any activities as formally linked to e-Devlet, and most of them are hired through subcontracting mechanisms where no single side has an incentive to register the linkages (Yıldırım et al., 2023). As Öztürk (2023) explains, domestic workers and migrants working for construction companies in Türkiye have different perceptions of their safety at work, reflecting the difference in structural positions of workers within the same regulatory system. In a similar fashion, Acar et al. (2025) discuss tough working conditions of the migrant labor in an industrial area in southern Türkiye, which persists despite the presence of formal OHS enforcement structures that cover the same areas.

The vulnerability described above is not unique to migrant workers, despite the paper's application of its findings to the case of migrants in Section 4, where the Syrian population was selected due to availability of data. As Öçal and Şenel (2021) point out, informal employment continues to be one of the characteristics of the Turkish labor market that is persistent and diverse at a regional level for any particular migrant group, because it tends to concentrate in those labor-intensive and subcontracting-abundant industries exemplified by the construction industry. Therefore, both native informal workers and migrant informal workers tend to share their worksite and sometimes even belong to the same subcontracting chain, although they differ greatly in terms of what administrative obstacle makes them unable to be formally registered as workers, namely a lack of proper documentation in the case of the migrant, and, in the case of the native worker, often a decision of either the employer or the employee themselves. The Digital Shadow Labor framework formulated in Section 3 can incorporate both scenarios in one structural situation, because the key aspect of the framework is not the reason of informality, but the way in which the digital governance system perceives both routes to informality.

The coronavirus disease 2019 (COVID-19) pandemic acted as an unexpected stress test of this system. According to İncili and Aysan (2023), Syrian citizens under temporary protection have suffered disproportionate disruption to their employment and income due to the pandemic, which is in line with a labor force that operates outside the formal systems of OHS and hence suffered less during the same time. Nonetheless, there is no literature which examines the problem from the lens of the intersection of governance and infrastructure. There is only empirical evidence of negative results such as poor perceptions of safety, harsher working conditions, and different levels of exposure to the pandemic without exploring if the enforcement digital governance infrastructure plays any role in causing such results. This is what this study will try to investigate and it will fit well into the context of one particular institution that is reported by Baykuş et al. (2024).

2.3 Theoretical Foundations

The theory of the digital divide in its fullest form identifies more than one consecutive stage of disadvantage and does not treat access in binary terms. Van Dijk (2005, 2020) formulated the causal model according to which the barriers include motivation, material and physical access, skills, and usage. At each stage, disadvantage imposes constraints on achieving a next one despite the motivation and abilities of a worker. Van Deursen and Van Dijk (2019) further elaborate the model by establishing that, even under high connectivity, material costs and credentialing costs are more significant than internet access for determining the first barrier. This insight has direct bearing on İSG-KATİP since, in this case, the barrier is not bandwidth but an administrative credential.

Ragnedda (2017) builds upon the existing work and incorporates a third-level divide associated with tangible benefits. Workers can obtain access and acquire skills, but they will not be enough to produce tangible benefits from the process. This insight is very important because the difference between inclusion and protection is relevant to the problem of physical safety of the workers. Based on the previous works, Ragnedda, Ruiu, and Addeo (2022) add one more dimension and demonstrate that digital and social exclusions feed off each other, thus reinforcing one another. The two forms of exclusion form a self-reinforcing loop instead of independent phenomena that can be solved separately.

The thesis of the system-level bureaucracy, stated above, gives the administrative tool by means of which individual-level barriers become barriers to state activity: digitalization does not just enhance discretion, but changes its location and sometimes removes it altogether. It is hardwiring the limits of who can be regarded as a legitimate subject of governance into the very system rather than letting one determine this through case-to-case discretion.

The criticism of the digital welfare state, formulated most clearly in the UN Human Rights Council report by Alston (2019), warns against the possibility of getting what he calls a digital welfare dystopia: an approach to governance that enhances the state's capacity for monitoring and punishment targeting the poor, while reducing its accountability to them at the same time, since there is no human decision-maker whom one can ask about his/her decisions or ask to make exceptions to the automated result. While the UN report concerns the issue of welfare benefits rather than OHS enforcement, the mechanism itself (automation leading to the increase of the state capacity regarding the registered subjects and reduction of its accountability to the unregistered) is directly applicable to the governance of safety discussed here.

The original formulation by Bovens and Zouridis (2002) has received considerable elaboration in the secondary literature, and this further scholarship elucidates the basis for the analysis presented here. Further studies in the field of public administration have demonstrated that the application of AI and ICT does not entail merely a uniform reduction in discretion; rather, it is a process that alters where discretion is located and who exercises it, often shifting evaluative discretion from street-level bureaucrats to systems designers without reducing discretion (Bullock, 2019; Bullock et al., 2020; Young et al., 2019). Busuioc (2021) argues that this relocation creates a distinct accountability problem: existing accountability forums, courts, parliaments, ombudsmen, were built to question human decision-makers, and struggle to attach responsibility to a system whose logic no single official can fully explain. Bannister and Connolly (2020) frame this as a risk-management problem for administration by algorithm specifically, while Busch, Henriksen, and Sæbø (2018) document, from the perspective of frontline public-service workers themselves, how digitized discretionary practices constrain the judgment those workers can still exercise. Peeters and Widlak (2018) offer the closest existing parallel to the argument developed here: they show that a public information system's data architecture, not just its formal rules, can silently exclude citizens who do not fit its categories, a phenomenon they term the digital cage. Section 3.4 returns to this parallel directly.

3. The Digital Shadow Labor Framework

This framework has all its components based on existing theoretical frameworks. However, the novelty of this approach is not to be found in the gates themselves, but in the entire discussion that is presented in Section 3.4 where the author argues that changing the context of the use of these theories to physical security enforcement will change the very nature of exclusion and the participants in the process. Those readers who have doubts about the novelty of the four gates can find the answer in Section 3.4.

3.1 Four Exclusion Gates

The DSL Framework views digital occupational health and safety (OHS) exclusion as a four-gate process instead of just one threshold of access. If a worker is unable to clear one gate, then the worker is opaque to all other governance processes down the line, regardless of any protections that may be provided by formal law, and regardless of whether or not the system functions as intended for those who are included in its system.

- Gate 1: Identity and Registration. Access to the governance systems, like İSG-KATİP, is conditional on having a verifiable national identity card, as well as an employment relationship that can be recognized legally. In order to pass through Gate 1, undocumented workers and those employed illegally (without a proper work permit) would be excluded, not because of any problems with the functioning of the system itself, but rather because they do not qualify as having the kind of relationship that the system recognizes. This relates to the motivational and material-access level of the divide proposed by van Dijk (2005, 2020), moving from internet access to the requirement of a credential. It follows the idea of van Deursen and van Dijk (2019) that, even in highly connected settings, it is material and credential requirements, not connectivity alone, that make up the first-level divide.
- Gate 2: System Navigation. Even when a person is officially recognized as someone capable of working and is able to apply for a job, or a small subcontractor who is officially recognized, will not necessarily have the ability and the tools necessary to navigate a compliance system well. In other words, there might be a difference between having the right to work legally and being able to use that right in practice and registering successfully. This issue fits the skills part of the digital divide: the ability to use a system rather than just have the credentials to start using it. A small subcontracting company run by a sole proprietor without the help of any administrators will have all the required credentials but will not keep the records properly, resulting in the creation of exclusion unseen by Gate 1.
- Gate 3: Data Visibility. Only those organizations who pass both the first and the second gates produce data. National statistics related to OHS results, based on social security and registration, will, therefore, reflect the statistics of those workers who have been registered rather than the

statistics of all workers actually present at construction sites. It results in the appearance of the third-level outcome-related divide described by Ragnedda (2017): the data infrastructure will become selectively blind and policy based on this data will inherit this blindness, although no specific decision has been made to exclude anyone.

- Gate 4: Accountability. The enforcement in the system is focused only on registered individuals, which means that the framework of accountability in this case works only with respect to the state records. The people that are not present in these records have no automated way of being protected, marked as being under threat, or identified as a victim of abuse, injuries, or even death. This is an example of the accountability reversal described by Alston (2019), yet applied to safety rather than to welfare – the system is made much more accountable for its outputs and much less accountable for what cannot be observed exactly when it should cover its full scope of responsibility.

These four gates work additively and not separately. In case a worker passed the first gate and did not pass the second one, no information will be generated at Gate 3, and if a worker is rejected at any of the first three gates, he is made invisble for the accountability mechanisms discussed at Gate 4.

3.2 Conceptual Model

As illustrated in Fig. 1, the four gates can be viewed as a funnel that the entire on-site workforce goes through, where attrition happens at each gate and not one entry point. At each level of the funnel, the size represents the decreasing percentage of the workforce that is legible to the governance mechanism. However, individuals that drop off the funnel at any of the gates are still present physically on-site and subject to harm although they become less and less legible to the governance systems meant to prevent that from happening. The difference between the width of the funnel at its beginning (the entire on-site workforce) and its end (the portion legible to the governance systems) is the population that this research argues is being overlooked in the process of OHS digitalization in Türkiye.

A succinct example illustrates the functioning of the funnel in action, without claiming any level of precision higher than the extent of support by the data. Take a construction worksite with three worker categories: (i) documented workers with administrative support at the firm level, (ii) informal domestic workers who are employed in such a way because it is more economically efficient, and (iii) undocumented migrant labor. In all three cases, the same physical risks occur. However, only the first category manages to pass all four gates since it has valid identity documentation, the firm is compliant with the İSG-KATİP legislation, generates SGK documentation and triggers an automated alarm signal in case the safety-specialist assignment of the firm expires. Category (ii), that of the domestic informal workers, may clear Gate 1 insofar as it has valid identity documentation, but does not form an employment relationship that can be registered since the informality occurs due to registration choice and not due to lack of documentation, thus placing this category at Gate 1 for different reasons than in the previous example. Category (iii) does not clear Gate 1. In all three cases, the physical risk is the same; what changes is the capacity of the governance system to observe, count and act after, which is the exact point of this framework. Figure 2 illustrates this three-category situation as a gate clearance matrix.

3.3 Propositions

It results in three hypotheses designed for later empirical tests, distinct from the case study described in Section 4.

• **Hypothesis 1**

• The width of Gate 1 barrier, operationalized as the share of the sector's workforce that has no valid work permits and/or registrable identity documents, is positively correlated with the degree of undercounting of OHS incidents and fatalities in the sector's official OHS statistics.

• **Hypothesis 2**

• Sectors with high proportions of small and undercapitalized subcontractors suffer stronger Gate 2 attrition effect than those dominated by large firms with compliance staff, irrespective of Gate 1 conditions.

• **Hypothesis 3**

• With increasing attrition at Gates 1–3, the difference between a sector's official fatality rate and its true fatality rate grows multiplicatively as opposed to additively because each gate limits the pool of population that can get through the next gate.

Direct testing of these hypotheses would involve collecting access-rate data. This is exactly what the framework predicts would be the hardest type of data to collect the methodology problem described in Section 6.2. However, there is still a partial way forward. Hypothesis 1 does not need any information on undocumented workers per se, only the indicator of the width of Gate 1 barrier on the sectoral level. The International Labor Organization (ILO) has developed a manual for estimation of informal employment in sectors without direct registries (ILO, 2013), including discrepancies between labor-force surveys and enterprise registration criteria. These indicators could be used to estimate the total number of people employed in a particular sector regardless of its registration and compared with the registered-versus-recorded fatality gap. Thus, it would not test the hypothesis by measuring the actual exclusion, but it could provide a basis for testing it at the sectoral level.

3.4 Theoretical Positioning

In comparison to the underlying theories on which it is built, the DSL framework has two distinct differences with respect to its counterparts. To begin, the traditional models of the digital divide (van Dijk, 2005, 2020; Ragnedda, 2017) have been built in order to provide an explanation as to why there exists unequal advantages associated with digital technology, which essentially means that there is some kind of disadvantage (loss) experienced due to the gap in information/economic opportunities. However, in the context of OHS compliance infrastructure, the gap in advantage changes into the matter of physical survival, hence changing the normative aspect of each gate while keeping the basic structure the same. In other words, exclusion from Gate 1 of any e-government service implies the loss of convenience, whereas exclusion from Gate 1 of OHS registration website entails loss of access to tool preventing fatal falls or machine accidents.

Second, Alston's (2019) criticism of the digital welfare state deals with systems that have the purpose of distributing benefits – in the case of exclusion, people are denied a benefit. By contrast, an OHS compliance system has an opposite purpose, namely that of limiting and monitoring the activities of employers, as opposed to distributing benefits to workers. Therefore, the harm done by exclusion does not consist in denying workers any benefit but in failing to apply the necessary control an unregistered employee's employer does not undergo any automatic inspection that would be done in case of registering the worker. This is what makes the accountability flip described in Gate 4 especially relevant in the context of safety and the reason why the most vulnerable group, in terms of risks, is also the one whose employer receives the least amount of automatic supervision.

This article's most similar conceptual predecessors are the concepts of digital cage (that an information architecture, besides all legal provisions, may exclude individuals who don't fit into its categories of data) and the study of the infrastructure-level bureaucracy that led to the Dutch daycare benefit scandal (Peeters & Widlak, 2023). In this scandal, an automatic fraud detection system had incorrectly excluded tens of thousands of families but there was no opportunity to rectify the mistake automatically. The common point between the studies is the claim that digital exclusion happens through data architecture and not through a discriminatory decision per se. The DSL Framework stands out on account of the scope, not the nature of the framework; while Peeters and Widlak consider the citizens that are part of a system but are unjustly discriminated against due to their status in the system, the four gates under discussion herein refer to a population that will not even be in the records of the system to begin with. The former type of invisibility is in many ways a more complete one because, at the very least, the citizen who has been unfairly marked down may appeal the decision concerning him or her, but the latter cannot even do that much.

4. Case Application: Türkiye's Construction Sector

4.1 Gate 1 in Practice: Identity and Registration Barriers

The labor force working in Turkish construction companies usually finds itself working outside the scope of the Temporary Protection route for a completely valid formal work permit or outside the realm of an employer who is prepared to go through the rigmaroles of a formal registration process because of the costs involved (Yıldırım et al., 2023; Çınar, 2019). In such a scenario, the İSG-KATİP e-Government and Turkish National Identity Card validation process becomes more than just a small obstacle to overcome, but it serves as a complete barricade that makes registration impossible before the issue of compliance in the workplace can be addressed. The study of Öztürk (2023) confirms this mechanism by providing results of a comparative analysis between domestic and migrant workers' safety perceptions.

The problem occurs not only in relation to migration but also concerns domestic informal workers in the Turkish construction sector who work independently of the issue of Syrian migration. In such a case, the worker faces an analogous yet analytically distinct case of the same problem: employment which is deliberately conducted off the books to avoid making social security contributions leads to the same absence of registration in this case as in the case of an undocumented migrant, notwithstanding the lack of a problem with identity documents within the nation's borders. Both cases can be viewed as Gate 1 cases in the present paper since in both instances the same non-registrable status is reached before any considerations of navigating the system. However, the causes of the problem are different and should be noted explicitly: an undocumented migrant cannot register because of a credential problem while a domestic informal worker is usually absent from the registry due to his/her own or his/her employer's decision to register. The latter implies that the difference is more related to the Gate 2 considerations of the matter. From a policy perspective, the importance of the difference in the cause of the problem is clear: a credential problem requires an analogous solution to what is proposed in Section 6.1 while a registration choice calls for a different policy instrument altogether.

4.2 Gate 2 in Practice: System Navigation Capacity

However, Turkish construction companies depend heavily on subcontracting, in which the general contractor recruits several smaller businesses, some of which have a rudimentary administrative structure. According to Baykuş et al. (2024), the persistent difference between the regulations and the practices regarding excavations and site safety is consistent with the legal responsibility of compliance held by subcontractors who lack the organizational capacity to implement the compliance procedure properly. Institutional changes suggested by Yıldırım et al. (2022) are based on the fact that the existing set up leaves considerable numbers of construction companies with no administrative resources needed for meeting the digital compliance requirement.

The lack of specialized administrative staff in a subcontractor can make them unable to keep İSG-KATİP records even if all employees have the right documentation and hence create Gate 2 leakage regardless of the Gate 1 obstacle described earlier. In other words, the analytical importance of the

above situation consists in the fact that Gate 1 and Gate 2 restrictions cannot be viewed as overlapping only. Thus, having all workers documented and hence formally employed does not guarantee their staying within the system at Gate 2. It means that formalization efforts targeting only documentation status will deal with only a part of the gap revealed with the DSL Framework.

4.3 Gate 3 in Practice: What the Data Can and Cannot Show

The study is based on secondary data obtained from the International Labour Organization (ILO), Eurostat of the European Commission, and the Social Security Institution of Türkiye (SGK). All data used in the study are publicly available from the respective official sources. The strongest evidence supporting the Data Visibility gate has been obtained by Özcan and Durukan (2026) from their analysis of data collected from the social security system in Turkey between 2014 and 2024. According to the authors' findings, construction has been accounting for 11.98% of insured employment but 31.94% of occupational fatalities during the same period, which means that there is a higher level of risks in this industry, almost threefold compared to its size in terms of employment, as shown in Fig. 3 below. The result is significant on its own and, in terms of the current research, may be regarded as a conservative one.

Aksu et al. (2022) establish that informal-sector effects of Syrian migration are concentrated precisely in construction, meaning that a substantial share of the sector's actual on-site workforce sits outside the population from which the 31.94% fatality-share figure is drawn. Whether this implies the true fatality concentration is understated depends on an assumption this paper cannot verify directly for Türkiye: that informal and undocumented construction workers experience fatality risk at rates comparable to, or higher than, their registered counterparts. This assumption draws support from international reviews of migrant OHS outcomes generally (Moyce & Schenker, 2018; Hargreaves et al., 2019), but those reviews were not conducted on the Turkish undocumented-labor population specifically, and the inference from one population to the other should be read as plausible rather than demonstrated.

A reasonable counter-narrative deserves acknowledgment rather than dismissal. Employers relying on undocumented labor have a strong incentive to avoid any incident that could trigger scrutiny of the entire site, and may respond by assigning undocumented workers to lower-visibility, more closely supervised tasks rather than the highest-risk assignments. If this pattern holds, informal workers' per-worker fatality rate could be lower, not higher, than that of registered workers performing more technically demanding tasks, which would weaken rather than strengthen the undercount claim. The paper does not have the data to adjudicate between these two possibilities, and it treats the undercount hypothesis as the more policy-relevant one to investigate further, not as an established fact. That which cannot be disputed anymore is what follows and is more firmly grounded in reality: the numbers of Özcan and Durukan (2026) refer only to the registered workforce, whereas a significant percentage of the actual population in the industry falls outside their definition. Therefore, the policy implication that arises from this more specific but nevertheless more grounded finding is that resource distribution and inspections will be guided by numbers of the registered workforce, an incomplete representation of the actual population, regardless of the risk difference to come.

4.4 Gate 4 in Practice: Automated Enforcement Without Protective Discretion

The automatic imposition of penalties on the part of İSG-KATİP's penalty logic when an obligation becomes overdue falls squarely within the framework of the system-level bureaucracy outlined by Bovens and Zouridis (2002). This results in a system of governance with a high level of accountability in its narrow definition. An employer with a registered but non-compliant work force gets automatic sanctions imposed on him. This way, the new design offers a marked advantage over discretionary enforcement since it will be consistent and not prone to bargaining. The same design has no mechanism for making an action on the discovery of an unregistered worker at a dangerous place. A street-level bureaucrat faced with such an occurrence has at least the discretion to act informally, report the incident through some other channels or just exercise his judgment on the case. The design which only knows registered relationships has no such means within itself. The resulting state of affairs matches what Alston (2019) describes as a system where the accountability is directed not toward the persons served by the system but toward its own documents. In the current case, the mechanism controls physical safety instead of benefits eligibility and the consequence of non-compliance is also more drastic: it is not denial of payment but unregistered injury or death.

4.5 Cross-Gate Interaction in the Turkish Case

The four barriers are not discrete filters applied to different groups of laborers. The construction sector in Turkey is such that the worker will encounter a number of these barriers at one time, and their interaction results in an effect of exclusion that is more than just the addition of its individual components. A Syrian laborer working for an under-capitalized subcontractor faces the combined force of the Gate 1 barrier, where they lack documentation of work permission and the Gate 2 barrier due to the inability of the subcontractor in question to register them for work permits in light of its limited administrative capacity. This interaction mirrors what is described by the inequality loop presented by Ragnedda, Ruiu, and Addeo (2022), where it is not so much that one barrier is applied to one specific group of laborers but a common structural position which makes workers susceptible to all these barriers at once. As such, the consequence of Gate 3 undercounting seen in Özcan and Durukan (2026) in their analysis of social security records will not be found evenly spread out among all unregistered laborers but among the very laborers who have faced compounded exclusion, and hence the groups least likely to have any discretion on the part of the enforcement system work for them through Gate 4.

5. Discussion: Legal Boundaries and Democratic Accountability in Digital OHS Governance

5.1 Legal Boundaries in the Digital Ecosystem

In the case of Turkey, the issue of responsibility in terms of the law is that which is not resolved under the current occupational health and safety (OHS) regulatory framework: who is responsible in cases where there is a failure to register a worker whose existence in the hazardous workplace has been established? The legal framework of Turkish OHS laws, especially Law No. 6331, stipulates that the duty of care towards a worker should be extended by the employer to all workers in a site regardless of their registration status; moreover, the duty of care towards the citizens in terms of administrative law is recognized by the state and does not, per se, depend on the registration status of the workers. Yet, the technical infrastructure of the enforcement of the aforementioned laws can address the relationship between the actors only if it can recognize them, thus creating a discrepancy between the guarantees of law and the capacity of enforcement. Such a discrepancy is not due to an inherent deficiency of the laws but rather to a discrepancy between law and enforcement mechanism, and it constitutes exactly the type of discrepancy which Turkish administrative law would consider important, i.e., the case where there is no discretionary channel left through which the state could perform its duty of care to the population it does not recognize. Cooper et al. (2022) suggest that algorithmic accountability requires relational approach to responsibility, i.e., that one has to determine which actor is responsible at each step of system's implementation. In this regard, the issue is not so much whether İSG-KATİP is working correctly as it largely does, but whether the people who designed the system and run it have to shoulder any responsibility in accordance with the state duty of care doctrine. Another point that can be made regarding the accountability of such forums has been made by Busuioc (2021), who has pointed out that while courts, parliaments, and ombudsmen are designed to question the decisions of humans, it is extremely difficult for them to assign accountability when the exclusionary principle is outside the jurisdiction of any single authority and therefore is not easily explainable. Metcalf et al. (2021) have proposed that algorithms should undergo an impact assessment in order to highlight this form of construction stage exclusion before full implementation.

Failure to examine this kind of exclusion has practical implications for those affected. Peeters and Widlak (2023) provide a clear example of how a lack of examination of the criteria of exclusion within an automated system may lead to: tens of thousands of people being erroneously classified as fraudsters because of the functioning of an algorithm designed to match data, which does not provide anyone with a means to challenge the decision made regarding them, even when there was no such decision made about them. The situation in Turkey considered in this paper is different from the previous one in one very important way, namely that the informal and undocumented construction workers are not incorrectly identified by the İSG-KATİP system; they do not even get included in the system.

This discrepancy needs clear recognition. The formal employer is bound to a strict and mostly automated system of compliance that leaves little room for negotiation. Meanwhile, the informal employer, having used a significant amount of informal labor, faces in effect no such system at all for that portion of employees because the system set up to control the registered relationship lacks any native ability to detect its absence. Turkish law on workplace safety does not intend such asymmetry, as it covers formally all workers, independent of their registration. However, intentions of the legislature and abilities of administration are different matters.

This critique may be objected to on the grounds that it places blame where it does not belong: the informality and unauthorized migration existed in the labor market prior to digitalization and cannot be blamed on a compliance system for not being solved by it. This is a valid point and needs to be seriously considered. Digitalization did not invent the informal labor market in Turkey nor did it cause the labor migration from Syria; and regardless of how effective the online OHS registration system would be, there is no way it can take place of the relevant policies of immigration and labor formalization. However, this does not diminish the importance of the issue under consideration. A system that automates compliance checks while ignoring its weaknesses is not only neglecting the problem. By turning the administrative hole from a visible one to an invisible one, which provides no data and therefore calls for no analysis whatsoever, it creates a condition where a problem is not even recognized as such. The responsibility that is being placed in this paper is more modest than trying to solve the issue of informality per se. It is about making sure that the automated system becomes aware of its own weaknesses, like through algorithmic impact assessment, for instance.

5.2 Democratic and Social Resilience Implications

Beyond individual legal accountability, the pattern documented here bears on the health of democratic governance itself, and it is worth naming the specific mechanism at stake rather than invoking democratic resilience as a general good. The mechanism is administrative due process in its most basic sense: the expectation that a state action affecting a person's safety and legal interests should be responsive to that person's actual circumstances, and correctable when it is not. A system-level bureaucracy that cannot register a worker also cannot extend that worker any due-process channel, since due process presupposes a legible party to whom process is owed. A state whose primary safety-monitoring infrastructure only sees the workers it has already formally recognized progressively loses the capacity to be held accountable, through ordinary administrative or legal channels, by or on behalf of everyone else. This is consistent with Liu, Zhou, and Liang's (2025) systematic review finding that digital-inclusion research in public services has developed extensively around welfare, health, and general administrative access, but has not yet been extended to safety-enforcement infrastructure specifically, leaving exactly this due-process dimension underexamined in the literature. Ragnedda, Ruiu, and Addeo's (2022) inequality loop is instructive here: informal and migrant status produces digital exclusion from OHS governance, which in turn produces data invisibility, which in turn weakens the political and statistical case for policy attention to the same population, reinforcing the original exclusion in a cycle that digitalization, left unaddressed, tends to accelerate rather than interrupt.

5.3 A Global North-South Comparative Note

Much of the algorithmic-accountability literature cited in this paper, including the FAccT venue scholarship of Cooper et al. (2022) and Metcalf et al. (2021), developed in response to automated systems in Global North welfare and criminal-justice contexts, where the excluded populations are typically citizens interacting with domestic bureaucracies. Türkiye's construction-labor case suggests that the underlying mechanism, discretion loss coupled with registration-dependent visibility, travels readily to middle-income and Global South labor-governance contexts characterized by large informal sectors and mixed migrant-domestic workforces, even where the excluded population includes non-citizens with a fundamentally different relationship to the state than the welfare recipients that motivated the original theory. This paper's application to Türkiye is offered as a single case rather than a generalizable claim, but the structural similarity to informality patterns documented well beyond Türkiye (Cook & Rani, 2023) suggests the DSL Framework's four gates may travel to other national OHS digitalization programs facing comparable informal-employment conditions, particularly across the wider region and in other middle-income economies pursuing similar e-government-integrated labor enforcement.

6. Policy Implications and Conclusion

6.1 Toward Inclusive Digital OHS Governance

Three potential design responses are readily discernible from the four-gate framework, targeting particular junctions in the funnel sketched out in Section 3.2. First, the impact assessment of algorithmic systems (following the approach set out by Metcalf et al., 2021), should take place for OHS digitalization projects not only before implementation but also after implementation, and it should focus on which populations are structurally disadvantaged in terms of the exclusion of registration logic rather than merely on how the system works for its already registered population. Second, a bounded discretionary pathway for inspection action (a documentable procedure through which an inspector/labor authority can raise red flags regarding the on-site presence of an unregistered worker) would restore some of the protection capability that is typically lost due to system-level bureaucracy (Bovens & Zouridis, 2002) while still retaining consistency gains which motivated the digitalization effort. Third, formalization pathways which follow the ILO Recommendation 204 (International Labour Organization, 2015) are a solution to the fundamental problem by offering more legal ways to enter registrable employment, thereby shrinking Gate 1 losses. These three design responses are complementary rather than substitutes to each other since they each target a different gate and no single design response closes the funnel identified above. Fourth, and related to the data visibility problem described in Section 4.3, national OHS statistics which are calculated exclusively using registered social security records should be clearly defined as being coverage-bounded, as opposed to presenting them as sector-level OHS statistics, where possible; when such coverage-based figures are complemented by independent estimates of sector size (in the same way that the broad size of informal economy is estimated) the figures such as construction fatality share presented by Özcan and Durukan (2026) will be recognized as a floor, not a ceiling.

6.2 Contribution, Limitations, and Future Research

Conceptually, this paper offers an innovative perspective by combining the theories of digital divide, system level bureaucratic perspective, and digital welfare state critique in the realm of occupational safety governance, where the theories have not been used before. The developed theoretical model is based on the empirical findings from OHS literature related to Syrian migrant and informal labor force in the construction sector of Türkiye.

This analysis reveals a rather obvious and in some sense self-evident limitation. There are no datasets available which provide estimates for the usage rates of İSG-KATİP and e-Devlet applications for undocumented Syrian construction workers, meaning that the case application in section 4 rests on triangulation of other empirical findings as opposed to one specific measurement of the exclusion predicted by the framework. This corresponds to the Gate 3 assertion made by the framework: a population invisible to data collection infrastructure cannot be easily measured by researchers depending on this very infrastructure. Nevertheless, correspondence with the theory does not amount to confirmation, and Propositions made in Section 3.3 await testing and confirmation in this paper.

Fieldwork carried out at the site level combined with the governance data collected by Özcan and Durukan (2026) with the aid of SGK could provide the first ever empirical test of Proposition 1 by means of comparing Gate 1 barriers to sectoral statistical undercount.

A fourth limitation is that of scope: the Turkish construction industry is overwhelmingly male in composition, following the trend common to many countries where construction and transport sectors remain two of the most male industries even if a significant proportion of informal workforce consists of women (Bonnet et al., 2019). The interaction between gender and the four gates presented in this framework is not explored in this paper, neither are differences in the configuration of these gates experienced by women working in the other informal sectors adjacent to the construction sector.

An additional research avenue worth exploring in this case is the comparative one, namely the application of the four-gate analysis approach to the OHS digitalization projects in other middle-income countries featuring large informal and migrant workforces will allow identifying if the mechanism revealed in the case of Türkiye is typical for digital labor governance in the conditions of high levels of informality or a uniquely Turkish phenomenon, discussed in the present study.

A third limitation of the paper concerns its use of the secondary literature created with other objectives in mind. The papers discussing the issue of OHS in Turkey, listed in Section 4, did not aim at examining the access to digital systems. Moreover, the digital governance theory utilized in Section

3 was not originally created with the goal of studying the issue of OHS. For this reason, the presented synthesis must be regarded as the theoretical and plausible explanation of the mechanism supported by the convergent evidence rather than the test of a hypothesis. This is a common feature of the theory-building works that identify the gap but lack the necessary data infrastructure to explore it.

Declarations

Ethics approval and consent to participate

This study does not involve human participants, human data, or human tissue. The analysis was conducted entirely using secondary data obtained from publicly available sources. Therefore, no ethical approval was required for this study. Not applicable. This study used publicly available secondary datasets and did not involve the recruitment of or direct interaction with human participants.

Clinical trial number

Not applicable.

Consent for publication

The corresponding author has reviewed the manuscript and provide their full consent for publication in Discover Global Society.

Competing interests

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Author Contribution

The corresponding author has carried out tasks like conceptualization, methodology development, data analysis, and the original draft alone. The co-author handled other tasks, such as data collection, subsequent revision, and document editing.

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Data Availability

The study is based on secondary data obtained from the International Labour Organization (ILO), Eurostat of the European Commission, and the Social Security Institution of Türkiye (SGK). The datasets used in this study are accessible through the respective official databases, and the relevant database links are provided in the manuscript and reference list.

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