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OCCUPATIONAL SAFETY IN AGRICULTURAL MACHINERY OPERATIONS

Nargiza Baxtiyorovna Ravshanova
Karshi State Technical University, Karshi, Uzbekistan.

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Abstract. *This narrative review compares the evidence on occupational hazards associated with tractors, combine harvesters, seed drills and field sprayers. Eight publications and technical documents were examined by machine, task, injury mechanism and outcome. A review of tractor overturns supports rollover protection, whereas a synthesis of adult education trials found no clear reduction in injury rates. Hospital records identify maintenance as an important injury setting. Combine and seed drill documents describe guarding and design controls, while pesticide studies distinguish exposure during mixing, loading and spraying. The evidence supports inspecting safeguards at the tasks where workers encounter the hazard. The available data do not establish injury rates for these machines in Uzbekistan.*

Keywords*: farm machinery, combine harvester, seed drill, field sprayer, occupational injury, guarding.*

Introduction. Hazards change as machinery moves from field operation to adjustment, cleaning or repair. A rollover protective structure addresses the consequences of an overturn during tractor operation [5]. During servicing, the immediate concern is whether a component can move while a worker is within reach. Insurance records identify the machines involved in reported injuries [3], while hospital records show that maintenance accounted for a share of the cases treated [4]. Together, these sources explain why a review of machinery safety needs to consider both the type of machine and the task underway.

A combine blockage brings a worker close to an auger. A raised seed drill presents a different hazard when a worker adjusts its components, and a sprayer can expose the operator while the machine is stationary during loading. Grouping all three under a single machinery injury category obscures the part of the task where prevention is possible [1,2,7,8]. This review asks which safeguards address these exposures and what the literature establishes about their effects.

Materials and methods. A targeted web search on 6 November 2026 located records in PubMed and PubMed Central and publications from HSE, ISO and EFSA. Queries combined machinery injury with tractor rollover, combine blockage, seed drill safety, and pesticide mixing, loading or application. English-language sources were included if they reported injuries, evaluated a preventive intervention or specified a control for one of the four machine groups. Eight sources met these criteria. Evidence was grouped as injury surveillance, intervention research, exposure research or technical guidance. The review used a narrative synthesis without a formal quality appraisal or pooled analysis.

For each source, the synthesis identifies the machine or task, the hazard, and the outcome or safeguard described. The comparison follows the point at which exposure occurs, such as clearing a combine blockage, adjusting a seed drill, or mixing and loading pesticide for a field sprayer.

Injury counts, intervention effect estimates and exposure findings are interpreted separately. Where a source describes a safeguard without measuring its effect on injuries, Table 1 presents it as technical guidance. Reported estimates retain their original study population and outcome.

Results. South Korean insurance records distinguish injuries by machine type, including tractors and combines, but the insured machine counts do not measure hours of exposure [3]. In a North Dakota trauma-center series, 24.5% of farm-machinery injury cases were associated with maintenance [4]. This percentage describes the admitted cases. It cannot estimate the probability of injury during a maintenance task.

Table 1

Findings and controls by machinery task.

Machine and exposure	Finding and evidence type	Control and interpretation
Tractor driving on uneven ground. Overturn and operator crushing.	Review of fatal overturns supports rollover protection [5].	Use compatible rollover protection with an operator restraint [5].
Combine blockage clearance. Contact with auger or descent of header.	Claims identify combine injuries [3]. HSE identifies hazardous components [1].	Guard moving parts and isolate the drive before access. Secure a raised header as directed by the manufacturer [1].
Seed drill adjustment. Crushing near a raised or moving assembly.	ISO specifies seed drill design and verification requirements [2].	Check model-specific supports and safe adjustment instructions. Injury reduction was not quantified [2].
Field sprayer mixing, loading and application. Contact with pesticide.	Meta-analysis identifies task as an exposure determinant [7]. EFSA models phases separately [8].	Assess transfer and application separately. Follow product-specific protection requirements [8].

The reported outcomes differ across machine groups. Tractor studies address fatal injury, insurance records describe reported incidents, and pesticide studies characterize exposure. These outcomes cannot be combined into one comparative estimate.

The combine illustrates why guarding and isolation are separate controls. A fixed guard limits access to an auger during operation. Once the guard is removed, as shown in Figure 1, the auger becomes accessible. The maintenance procedure must address the possibility of rotation as well as the descent of any raised assembly. HSE identifies blockage clearance and maintenance as tasks that require specific precautions [1].



Figure 1. Combine auger with a fixed guard in place (A) and an exposed danger zone after guard removal (B). Schematic based on [1].

For a seed drill, the location of a support and the procedure for securing a raised assembly depend on the model. The public summary of ISO 4254-9 establishes the scope of the design requirements and the need for manufacturer instructions [2]. Figure 2 shows what to verify before access. The machine manual provides the specific procedure.



Figure 2. Control sequence before access to a machinery danger zone. Author's synthesis based on [1,2].

Discussion. The Cochrane review pooled three adult education trials and reported an injury rate ratio of 1.02 (95% CI 0.87–1.20) [6]. The interval includes both a reduction and an increase in injury rates. That finding concerns education programmes. It does not measure the effect of repairing a guard, fitting an operator restraint or securing a raised component before service.

For sprayers, a review of 71 studies identified task, frequency and duration among the variables used to characterize pesticide exposure [7]. An inspection that focuses only on the spray run would miss mixing and loading. Separating those activities in farm records would allow exposure controls to be checked at each stage [8].

A proposed field checklist for farms in Uzbekistan would record the machine model, the task underway and the safeguard available at the time. During harvest, an incident record should distinguish a moving combine from work at a stopped machine and note whether a guard was removed or the header was raised. During sowing, records should distinguish transport and folding from adjustment and service. Spray records should identify the product and separate mixing, loading and application. Recording task hours where feasible would allow comparisons between tasks with different exposure times.

The included insurance and hospital studies describe specific populations. Their injury figures cannot be transferred directly to farms in Uzbekistan. The cited standards and guidance explain control requirements or procedures, and the reviewed sources provide no comparable injury reduction estimates for combine guarding or seed drill supports.

The evidence on tractor rollover protection addresses fatal injury directly. The evidence on combine and seed drill controls largely describes how to prevent access to moving parts or movement of raised assemblies.

For sprayers, exposure should be examined by operation phase. A farm-level assessment can therefore record the safeguard and the task together, then link them to injury or near-miss reports.

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