

Tractor Rollover Accidents: A Review of Factors and Safety Measures

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Abstract. This paper focuses on tractor rollovers because they account for more than half of all the tractor-related deaths. As per international Labour organization more than 1247 deaths happen annually and more than 60,000 people get seriously injured due to tractor rollover. In addition, farm tractor operational safety principles are also highlighted. It has been observed through this study that the tractor rollovers occur when a tractor tips over, potentially crushing the operator. Furthermore, rollovers can happen on any terrain, but they are more likely to occur on sloping ground or when making sharp turns at high speed. Other factors that can contribute to rollovers include hitting obstacles, improper use of implements, and not using a rollover protective structure (ROPS) or seat belt.

1 Introduction

Farm tractors serve a vital role in farm activities. Nevertheless, their usage poses significant injury risks, as they are susceptible to rolling over either sideways or backwards. Despite efforts to prevent such rollovers, the chances of success are limited. When a tractor tips over and overturns, known as a tractor rollover, it can lead to severe consequences, potentially crushing the operator. These rollovers are frequently reported on sloping terrains, especially during sharp turns at high speeds. However, data indicates that rollovers can also occur on flat land after colliding with obstacles or due to inappropriate use and hitching of implements [1, 2].

An accident involving a tractor overturning invariably results in serious harm to the operator. In some cases, the operator may lose their life or sustain severe injuries, preventing them from returning to work for extended periods, possibly months. Moreover, the tractor and other equipment involved may suffer extensive damage, necessitating major repairs [3, 4]. Even in cases of minor damage, valuable time is lost in repairing and restoring the tractor's functionality. While safety cabs have been installed in most agricultural tractors, reducing the risk of death or injury, the underlying causes of tractor overturning persist due to factors like the high center of gravity and the frequent use of tractors on sloping or uneven terrain [5- 8].

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2 Tractor Accidents: A Global Concern

Farm tractors are a vital part of agricultural production, but they can also be dangerous. In the United States, tractor accidents result in an estimated 800 fatalities annually, with at least 40 others injured for each person killed. Overturns are responsible for more than half of the fatal tractor accident

Globally, the rise in fatal injuries caused by overturned farm tractors is a matter of increasing concern. Agriculture, including tractor-related incidents, had a worrying fatality rate of 44 deaths per 100,000 workers in 1991, making it one of the most hazardous industries. Consequently, farm tractors have been identified as the most hazardous machinery on farms in the United States.

There are a number of factors that contribute to tractor rollovers, including:

1. Operator error: This includes driving too fast, making sharp turns, or not using a rollover protective structure (ROPS).
2. Tractor condition: A tractor that is not in good working order, or that is overloaded, is more likely to rollover.
3. Environmental factors: Rollovers are more likely to occur on sloping terrain or in areas with obstacles.
4. There are a number of things that can be done to reduce the risk of tractor rollovers, including:
5. Using a ROPS and seat belt: These safety features can help to protect the operator in the event of a rollover.
6. Operating the tractor at a safe speed: This will help to give the operator more time to react to hazards.
7. Avoiding sharp turns on uneven ground: This is one of the most common causes of tractor rollovers.
8. Making sure that loads are properly hitched: This will help to prevent the tractor from becoming unstable.
9. Being aware of the surrounding environment: This will help the operator to identify hazards and take steps to avoid them.



Fig. 1. Fatalities due to tractor overturn in the US annually between 2005-2009.

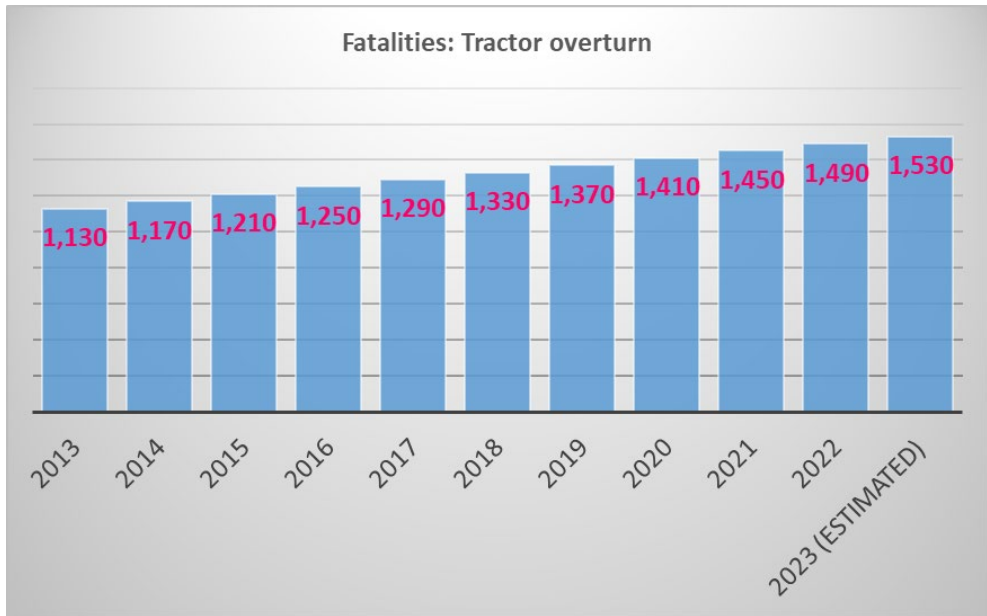


Fig.2. Global fatalities due to tractor overturn in the past decade

As one can observe from figure 2, the number of global fatalities due to tractor overturn has been steadily increasing in recent years. In 2013, there were 1,130 fatalities, and by 2023, the estimated number of fatalities is 1,530. This is a significant increase, and it is a cause for concern.

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7. Avoiding sharp turns on uneven ground: This is one of the most common causes of tractor rollovers.
8. Making sure that loads are properly hitched: This will help to prevent the tractor from becoming unstable.
9. Being aware of the surrounding environment: This will help the operator to identify hazards and take steps to avoid them.

By following these safety tips, farmers can help to reduce the risk of tractor rollovers and protect themselves and their families.

2.1 Tractor-Related Accidents in Agriculture

Agriculture is one of the most dangerous industries in the United States, with tractor-related accidents accounting for around 32% of fatalities and 6% of non-fatal injuries. Over 50% of these accidents are attributed to tractor overturns.

2.2 Factors Contributing to Tractor Accidents

There are three major factors that contribute to tractor accidents:

1. **The operator:** The operator's actions can play a significant role in preventing accidents. For example, driving too fast or making sharp turns can increase the risk of a rollover.
2. **The tractor:** The condition of the tractor can also contribute to accidents. A tractor that is not in good working order or that is overloaded is more likely to rollover.
3. **The environment:** The environment in which the tractor is operating can also be a factor. For example, operating a tractor on sloping terrain or in areas with obstacles increases the risk of a rollover.

2.3 Preventing Tractor Accidents

There are a number of things that can be done to prevent tractor accidents, including:

1. **Using a rollover protective structure (ROPS) and seat belt:** These safety features can help to protect the operator in the event of a rollover.
2. **Operating the tractor at a safe speed:** This will help to give the operator more time to react to hazards.
3. **Avoiding sharp turns on uneven ground:** This is one of the most common causes of tractor rollovers.
4. **Making sure that loads are properly hitched:** This will help to prevent the tractor from becoming unstable.
5. **Being aware of the surrounding environment:** This will help the operator to identify hazards and take steps to avoid them.

3 Additional Safety Tips

In addition to the above, there are a number of other safety tips that can help to prevent tractor accidents. These include:

1. **Taking breaks:** Continuous and extended farm tractor operation without rest can become hazardous. It is recommended that drivers limit themselves to 8-10 hours of driving per day to avoid stress and tiredness.
2. **Training:** Operators should be properly trained in the safe operation of tractors.
3. **Inspecting the tractor:** The tractor should be inspected regularly for any signs of damage or wear.
4. **Maintaining the tractor:** The tractor should be properly maintained to ensure that it is in good working order.

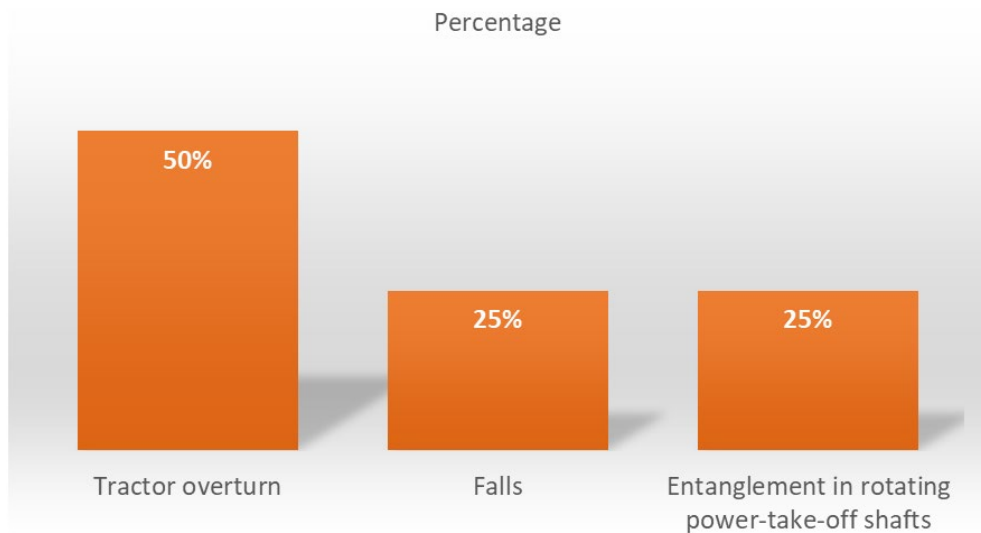


Fig. 3. Percentage of Tractor accidents: Overturn, falls, entanglement in rotating power-take off shafts.

Modern tractors come equipped with rollover protection systems (ROPS) designed to safeguard operators in the event of a tractor overturn. It is crucial to understand that while ROPS prevents the operator from being crushed during an overturn, it does not entirely eliminate the possibility of tractor overturns. This feature holds particular significance for open-air tractors, where the ROPS consists of a steel beam extending above the operator's seat. In the case of tractors with enclosed cabs, the ROPS is integrated into the cab's frame, providing additional protection. With an enclosed cab and ROPS, the likelihood of severe injury is further reduced, as the operator benefits from the protection of the cab's sides and windows.

In summary, farm tractor accidents commonly occur due to:

1. Rollovers
2. Power take-offs
3. Falls from tractors
4. Improper hitching of equipment
5. Tractor operations, and
6. Towing activities.

Table 1. Statistics of accidents

Cause	Percentage of Tractor-Related Deaths
Operating tractors on steep side slopes	33%
Excessive speed during sharp turns	25%
Sudden application of power to the rear wheels	20%
Towing loads not hitched to the drawbar	22%

The four most common causes of tractor-related deaths are all related to rollovers (table 1). This is why it is so important to use tractors with rollover protective structures (ROPS)

and seat belts. ROPS can significantly reduce the risk of death or serious injury in the event of a rollover.

Here are some additional safety tips for preventing tractor rollovers:

1. Always operate the tractor at a safe speed.
2. Be aware of your surroundings and avoid making sharp turns on uneven ground.
3. Make sure that loads are properly hitched to the drawbar.
4. Use a ROPS and seat belt at all times.

Table 2. Factors affecting the overturns

Factor	Description
Type of overturn	The most frequent type of overturn is to the side. Studies indicated that 75-85 percent of overturns are to the side.
Causes of overturn	Sharp turns, high loads, high speed, centrifugal force, field slope, tractor speed, turning radius, rear axle torque, and centre of gravity are all factors that can cause a tractor to overturn.
Modern safety features	Modern tractors are equipped with rollover protective structures (ROPS), improved hitch designs, weight distribution, wider wheel bases, better visibility, running lights, and adjustable seats.
Risks involved	Despite all these modern safety improvements, there are still risks involved while working with or operating a tractor. These risks can be reduced if the tractor operator understands operational safety precautions properly.
Safety precautions	Some safety precautions that can be taken to reduce the risk of a tractor overturn include:

Table 3. Global statistics on the number of farm tractors in use, the percentage of the farm tractors equipped with ROPS and the number of rollover fatalities per 100,000 farm tractors

Country	Number of farm tractors in use	Percentage of ROPS-equipped tractors	Rollover fatalities per 100,000 farm tractors
United States	13.8 million	96%	1.2
Russia	2.5 million	90%	1.5
China	19.4 million	85%	0.8
India	6.6 million	75%	2
Brazil	3.6 million	80%	1.3
South Africa	0.6 million	65%	1
Uzbekistan	0.3 million	70%	1.5
Kazakhstan	0.2 million	75%	1.2

From table 3 it is clear that the United States has the most farm tractors in use, followed by Russia, China, and India. The United States also has the lowest rate of rollover fatalities per 100,000 farm tractors, followed by Russia and China.

It is important to note that these statistics are only estimates, and the actual numbers may vary. Additionally, the rate of rollover fatalities may be affected by factors other than the percentage of ROPS-equipped tractors, such as the age of the tractors and the terrain on which they are operated.

Overall, these statistics suggest that ROPS are an effective way to reduce the risk of tractor rollover fatalities. However, it is also important to operate tractors safely and to be aware of the risks involved.

4 Conclusions

In conclusion, tractor rollovers are a leading cause of death and injury in agriculture. There are a number of factors that contribute to tractor rollovers, including operator error, tractor condition, and environmental factors. There are also a number of things that can be done to reduce the risk of tractor rollovers, including using a rollover protective structure (ROPS) and seat belt, operating the tractor at a safe speed, and avoiding sharp turns on uneven ground.

Despite the availability of safety measures, tractor rollovers continue to be a major problem in agriculture. There is a need for increased awareness of the risks of tractor rollovers and for more effective safety measures to be implemented.

The following are some additional conclusions that could be included:

- The number of tractor rollovers is increasing, and this is a cause for concern.
- Tractor rollovers can have devastating consequences, both for the operator and for their families.
- There are a number of organizations working to reduce the number of tractor rollovers, but more needs to be done.
- Farmers and other agricultural workers need to be aware of the risks of tractor rollovers and take steps to protect themselves.
- The study shows that the countries with the highest percentage of ROPS-equipped tractors also have the lowest rate of rollover fatalities. This suggests that ROPS are an effective way to reduce the risk of tractor rollover fatalities.
- However, it is important to note that these statistics are only estimates, and the actual numbers may vary. Additionally, the rate of rollover fatalities may be affected by factors other than the percentage of ROPS-equipped tractors, such as the age of the tractors and the terrain on which they are operated.

Recommendations:

The authors recommend that farmers and other agricultural workers take the following steps to reduce the risk of tractor rollovers:

1. Use a rollover protective structure (ROPS) and seat belt at all times.
2. Operate the tractor at a safe speed.
3. Avoid sharp turns on uneven ground.
4. Be aware of the surroundings and make sure that the area is clear before operating the tractor.
5. Keep the tractor in good working order and properly maintained.
6. Get proper training on how to operate the tractor safely.

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