EQUIPMENT RELATED INJURIES IN AGRICULTURE: AN INTERNATIONAL PERSPECTIVE

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Kewords: Agricultural implements/equipment/machines, agricultural injuries, agricultural accidents, and farm injuries

Abstract

Injuries related to agricultural equipment are a significant cause of morbidity and mortality both in high-income and low-income countries. Tractors are most often associated with severe injuries and fatalities. All age groups sustain injuries. Injuries to children are also prevalent because agricultural work place overlap homes in rural areas. In the majority of papers reviewed, preventive methods are mostly targeted at behaviour modification and effective medical facilities whereas only a few authors have highlighted design changes and passive measures for injury control. Effectiveness of suggested interventions are not discussed in majority of papers except those related to roll over protection structures, fodder cutting machines and thresher safety devices.

INTRODUCTION

A large proportion of the work force in the world is involved in agriculture or related occupations (FAO Yearbook, 1988). In a large number of countries farming is a part of the unorganised sector and not well covered by insurance or health services. Most of the reports published on agricultural injuries have originated from high-income countries [HICs] (Baker, Neill and Karpf, 1984; Cogbill and Busch, 1985; Cogbill et al., 1991; Heeg, Duis and Klasen, 1986; Jansson, 1989; Lehtola, Marley and Melvin, 1994; Zhou and Roseman 1994). There are very few reports from the low-income countries [LICs] (Field and Gong, 1982; Mufti, Ahmad and Majid, 1989; Mohan and Patel, 1992). Agricultural injuries are significant in both HICs and LICs. In the United States, non-farm machinery injuries decreased 79 percent but farm machinery injuries increased by 44 percent in the period 1930-1980 (Baker, Neill and Karpf, 1984). In Canada, fatalities from farm machinery increased 68% from the 1950s

to the late 60s (Howell and Smith, 1973). The agricultural workers' fatality rates were four to five times compared to for all other occupations in the USA (Simpson 1984 and Purchwitz and Field 1990, Crandall et al.1997). In Sweden, Lundqvist and Guastafsson (1992) reported agricultural injuries (50.2 persons per 1000 workers) were higher than industrial injuries (26.8 persons per 1000 workers). In LICs, in India, Mohan and Patel (1992) estimated 5,000 to 10,000 fatal injuries, 15000-20000 amputation of limbs and 150,000-200,000 serious injuries annually in three states of North India.

Farming involves work with biological and mechanical systems and the farmer has to work in adverse conditions of weather and poor infrastructure facilities. The work environment on a farm is distinct from the work environment in the industry. In many industrial settings learning is a formal process, whereas, on the farm learning is mostly informal as farmers learn from their own families or by personal experience (Knapp 1965). Since farming operations are seasonal, farmers work under constraints of weather making injury "inevitable" (Huston and Smith 1969). Very often they work alone and an injury-producing event may not be noticed for a long time. This makes farm injuries worse than similar injuries in a formal industrial set up (Cogbill and Busch, 1985; Cogbill et al., 1991; Monk et al 1986). Farm mechanisation has resulted in sophistication of operations, which makes the worker work alone for long hours but for short periods in the year, that requires the acquisition of special operating skills (Monk et al., 1986). In an industrial set up maintenance and repairs are a periodic feature done by specially trained man power where as farmer has to maintain and repair machines with available tools under time constraints which results in injuries (Nolen, 1963).

The farm injuries were reported to be severe, as quite a significant percentage (20 %) of them result in permanent disability (Cogbill et al. 1991). If a farmer is disabled by an agricultural injury he is doubly handicapped as he is not trained for any other activity (Knapp, 1965). If he is the main worker on the farm, the disabilities result in a greater economic loss to the family.

If disabilities from agricultural injuries are to be reduced we need to understand the epidemiology of agricultural injuries in both LICs and HICs, this paper compiles and assesses information on agricultural injuries and analyses the injury trends, their severity and available interventions. This study is under taken with the following objectives (1) To study the trends and patterns of agricultural equipment related injuries in HICs and LICs. (2) To compare the injury causation factors in HICs and LICs. (3) To study the injury prevention strategies. (4) To suggest control measures for injury prevention.

MATERIAL AND METHODS

A literature search from different databases, namely; AE-INDEX (database of Agricultural Engineering literature), CAB Abstract, Agris, Agricola (Agricultural literature database) and Medical Literature Analysis and Retrieval System (MEDLARS, created by the National Library of Medicine NLM), were used. The key words used were; agricultural implements/equipment/machines, agricultural injuries, agricultural accidents, and farm injuries. The search period was confined from 1940s till 1999. Only agricultural machine related injury papers were selected for this review. Because of difficulties in getting articles translated, only those published in the English language were selected for the study. The search was restricted to references available in computer databases. This review covers articles both from medical as well as engineering journals, which give in depth knowledge of injuries and machines involved. The definition of different terms used is given below.

Agricultural injury: An unintentional harmful outcome resulting from agricultural equipment while performing crop production activities. The injury occurs at farm, residence or on the road while working with agriculture equipment. It excludes articles on farm injuries due to fish farming, animal husbandry, pesticide poisoning and forestry.

Equipment: Any agricultural machine or tool used for crop production activity.

RESULTS AND DISCUSSIONS

Data on agricultural injuries and surveillance systems

There are no well-defined systems of recording agricultural injuries, as a standard definition of agricultural injury does not exist (Howell and Smith, 1973). Different surveillance systems are used for studies and this not only affects outcome but also hinders selection of preventive measures. Underestimation of agricultural injuries had been reported from HICs (Monk et al., 1986; Knapp, 1966). In LICs many of the injuries treated at home are never reported though they may have hampered work for several days. Such cases can be identified only in population based studies (Varghese and Mohan, 1990).

Surveillance systems can help in setting up priorities for injury control and detailed circumstances are required to be recorded to understand the mechanism of injury and controlling this problem (Stallones, 1989; Brazelton, 1976). The differences in surveillance systems cause differences in outcomes, as severity of injuries are lower in a population based survey than those studied in other situations like farm fatalities, hospital and emergency room studies (Layde et al., 1996, Pickett et al.,1995; Mohan and Patel, 1992; Schelp and Svanstrom, 1986). Howell and Smith (1973) reported that " there is a need to agree on a standard definition for an agricultural accident, and to develop criteria by which characteristics of the operator, circumstances of the accident, and design features of the equipment which have led to or permitted operator failure can be described".

Machines involved in agricultural injuries

A summary of studies on agricultural machine related injuries is given in Table 1. Among all agricultural machines, tractors are reported to be involved in 40% to 70% of the injuries and fatalities from HICs whereas in India and Pakistan tractors are reported to be involved in 5% and 31% of injuries. Augers and corn pickers come next in terms of causing injuries in HICs whereas these machines are scarcely used in LICs and no injuries were reported from these machines in LICs. Some of the machines like fodder cutting machines, threshers and hand tools currently causing injuries in LICs, are no longer in use in HICs. The machines involved in injuries vary with mechanisation level in farming activities as apparent from Table 1.

Hand tool injuries

Hand equipment like sickle and spade; are routinely used on farms in LICs. Operations like weeding, inter-culture, ridge formation, harvesting and irrigation channel making, are all done manually. Increasing mechanisation has reduced hand tools usage in HICs. Hand tools therefore, contribute to a large number of injuries in LICs. Spades and sickles were involved in 46 % of farm injuries in India (Mohan and Patel, 1992) whereas only one early study from HICs reported (Calandruccio and Powers, 1949) injuries (18%) with use of hand tools during 1929-48.

Table 1: Injuries caused by farm equipment as reported in studies from different countries.

Machinery	Study[@]												
	Young 1946 1935-43 USA	Calandruccio 1949 1929-48 USA	Lawrence 1955 Jan-Sep 1955 Alberta	Huston 1969 1955-67 Canada	Howell 1973 1969 Canada	Simpson 1984 1980 Canada	McKnight 1985 1975-81 USA	Cogbill 1985 1978-83 USA	Hansen 1986 1981-84 USA	Cogbill 1991 1978-89 USA	Etherton* 1991 1980-85 USA	Mufti 1989 1982-84 Pakistan	Mohan 1992 1987-88 India
Fodder cutter		-	-	2(01)	-	-	-	-	-	-	-	6(06)	64(11)
Thresher	9(05)[#]	-	-	2(01)	-	-	-	-	-	-	-	17(16)	10(02)
Tractor	34(18)	-	19(48)	169(68)	19(37)	18(43)	1940(60)	118(52)	25(40)	167(32)	1523(69)	32(31)	27(05)
Trolley	-	-	-	-	-	-	-	-	-	-	-	-	8(01)
Tillage tools	-	-	-	-	-	-	-	-	-	-	-	38(36)+	52(09)
Hand tools	-	113(18)	-	-	-	-	-	-	-	-	-	-	267(47)
Auger	-	-	-	10(04)	15(29)	7(17)	46(01)	-	12(19)	-	61(03)	-	-
Corn-picker	29(15)	-	-	-	-	-	-	57(26)	2(03)	42(08)	26(01)	-	-
Combine	7(04)	-	-	11(04)	6(12)	4(09)	93(03)	-	7(11)	-	53(02)	-	-
Engine	6(03)	-	-	-	-	-	-	-	-	-	-	-	27(05)
Mower	6(03)	-	-	3(01)	4(07)	-	-	-	3(05)	-	-	-	-
Bailer	-	-	-	4(02)	4(07)	3(07)	-	-	-	-	42(02)	-	-
Sugarcane crusher	-	-	-	2(04)	-	-	-	-	-	-	-	-	-
Bore well	-	-	-	-	-	-	-	-	-	-	-	7(07)	10(02)
Farm machinery[?]	-	79(13)	2(04)	-	-	-	-	-	-	168(33)	-	-	-
Miscellaneous	95(52)	466(69)	19(48)	46(19)	4(8)	10(24)	1150(36)	50(22)	15(22)	137(27)	511(23)	4(04)	133(18)
Total	186 (100)	658 (100)	40 (100)	247 (100)	52 (100)	42 (100)	3229 (100)	225 (100)	64 (100)	514 (100)	2216 (100)	104 (100)	576 (100)

@Author's name and date of publication, the period covered by the study and the country where the study was done.

#Number of victims (Percent)

*Fatality studies + Pesticide contact through sprayers included.

?Specific equipment is not mentioned

Fodder cutting machine and thresher injuries

Fodder cutting machines are used for chopping fodder for draft animals and domestic cattle. These can be either manually operated or power driven with electric motors or diesel engines. Threshers are power driven machines designed for threshing wheat during harvesting season.

Harvesting and threshing is now a combined operation in HICs, performed with combine harvesters. Fodder cutting machine and thresher injuries have not been reported by any HIC after 1969. However, Mohan and Patel (1992) recorded that these two machines caused 13% of total agricultural injuries, 11% by fodder cutting machines and 2% by threshers in India. In fodder cutting machine injuries, 45% of victims were children between 0-14 years. Similarly fodder cutting machines caused 6% and threshers 16% of injuries in Pakistan (Mufti, Ahmed and Majid, 1989).

The incidence of Abbreviated injury scale, AIS=2 and above were found to be higher in the powered fodder cutting machines (8.6 per thousand fodder cutting machines) as compared to the manual fodder (5.1 per thousand fodder cutting machines) cutting machines (Mohan and Patel 1992). The higher rate of severe injuries from powered fodder cutting machine indicates the role of higher levels of energy leading to more frequent and more severe injuries.

Thresher injuries can result from different causes. Children have crush/amputation injuries while they are playing with the rotor of the thresher. While threshing, the operator has to stand on a platform. If this platform is unstable or the feeding chute is low, the torso weight tends to push the hand into the threshing drum. In threshers having a higher incidence of injuries the length of the chute was found to be shorter with a narrow mouth opening forcing the operator to push the crop bundles into the threshing drum with more force, often resulting in hand injuries (Mohan and Patel, 1992).

Tractor injuries

In most reports, tractors have been found to cause major injuries and fatalities. Rees (1965) reported that in England tractor injuries were more severe than vehicular injuries. One in four-tractor injury was fatal as compared to one in twenty two of traffic injuries in England. A summary of tractor related injury studies is given in Table 2. Common causes of injury reported are overturns, run-over, falls, collisions, power-take-off injuries and injuries sustained while mounting and dismounting.

The cause of tractor injuries was attributed to poor ergonomic design also (Dupuis 1959, Bottoms 1980, Hammer 1991, Suutarinen 1992, Lee et al. 1996). In a case study on fifty tractor accidents, detailed analysis showed that 42% injuries occurred while getting onto or while moving out of the cab (Lee et al. 1996) and hitching and unhitching equipment led to 30% of injuries (Suutarinen, 1992). In LICs, another attribute of tractor injury is the usage pattern. Tractors are used for transportation in LICs (Varghese and Mohan, 1991). So the tractor injury victims are not only operators (only 8-15%) but also passengers and occupants of other vehicles (more than 50%) (Kumar, Mohan, and Mahajan, 1998, Field and Gong 1982). On the other hand, in one of the HICs the proportion of passengers involved in tractor fatalities was found to be only 5% in USA (Lehtola, Marley and Melvin 1994).

Table 2: Causes of injury in tractor related studies.

Study[@]	**Tractor injury mechanisms**						
	Overturn	Runover	Fall	Collision	Crushed	PTO or other part	Others
Muckala [1967]*,1964,USA,N=789	58$	8	13	6	9	3	3
Karlson [1979][*], 1961-75, Wisconsin, USA, N=415	52	12	11	-	-	10	15
Goodman[1985]*,1971-81,Georgia,USA, N=202	76	14	-	-	-	-	10
Tupi [1988][*], 1976-85, Finland, N=287	42	12	18	6	9	-	13
Lehtola[1994][*], 1988-92, Iowa, USA, N=136	56	17	-	14	-	-	13
Smithurst[1968], 1964-66, Australia, N=162	53	12	17	5	-	3	10
Suutarinen[1992],1987,Finland, N=403	-	-	-	-	-	-	28++
Ashby[1995],1995,Australia,N=125	-	14	18	12	-	14	42
Kumar[1998],1986,90,India,N=76	14	3	6	28	-	3	46**

$ Row percent
@ The study is included by author's name and date of publication, the period covered by the study and the country where the study was done.
* Fatality Studies
++ 42% were while getting in or out of the tractor, and 30% while hitching/unhitching implements to tractor
** included repairing,playing on tractor and working with implements

Involvement of children in tractor related injuries was quite alarming, as one third of victims were children as reported by Ashby and Day (1995). Of these, 18% were fall related causing three fatalities to children, 14% runover, 14% had a body part caught in a moving part of the tractor, and 12% resulted from collisions. In their study of injuries among children, half of them involved an operational tractor, with 40% found to be passengers on a tractor or a trailer. 7% each were either involved in tractor operation or moved too close to a tractor while tractor was in operation. 17% were playing in the vicinity of the tractor, 12% were climbing onto a tractor and 7% were playing with an unfitted tyre.

Childhood older age group injuries

Agricultural machine related injuries involved all age groups. Farmers, unlike industrial workers, work as long as they can along with their family members irrespective of age (Hansen 1986, Steuland 1990). Hansen (1986) reported that in younger age group injuries result because "a child going for fun with his father or they are naïve about power present in machinery and fail to give due respect". In older age groups reasons for injuries reported were economic necessity, slow reflexes, carelessness with increased experience, physiological impairments and other age related reasons (Hansen 1986, Goodman et al. 1985). This is the only profession where injuries occur in all age groups (1-90 years, Purschwitz and Field 1990).

Injuries among children are prevalent unlike other profession both because of work and play with machines. Muckala (1967) reported that 30-40 % of agricultural injuries are sustained by children and teenagers. Rivara (1985), Davis (1988) and Wilk (1993) found that nearly 300 children and adolescents suffer fatal farm injuries each year and another 23,000 to 27, 000 suffer non-fatal farm injuries. The causation of injuries were tractor, augers, animal related, farm machines and falls (Cogbill, Busch and Stiers 1985, Swansson et al. 1987, Salmi et al. 1989). Lund (1987) indicated that tractor related injury mortality was under 3% for adults and more than 19% for children in Denmark during 1980-84.

Mohan and Patel's study (1992) in India shows that children below 14 years of age were involved in 16% of all agricultural injuries. For all equipment, 30% of the injuries among 0-14 years old children were caused by fodder cutting machines, and in the 0-4 year age group, 50% of the injuries resulted from these machines.

Injuries in age group above 60 years are also reported in few studies. Pratt, Kinsen, Helmkamp (1996) reported that workers older than 65 years had five times fatality rate than workers of 16 to 64 years. Crandall et al. (1997) reported that one third of the fatalities were in 60 years or older age group. Voaklander et al. (1999) reported 32.8 per 100,000 population work related fatalities in which 82.8 % of the fatalities were in farm-owner operators. 30-40 % of victims were reported above 60 years in tractor related fatalities studies (Karlson 1979, Goodman 1985, Tupi 1988, Lehlota 1994) and 44% in machine related fatalities (Etherton 1991) in HICs. Non fatal injuries in above 60 years ranged 10-20 % in different studies of Table 1 from HICs where as from India the involvement of above 55 years were 9% (Mohan and Patel 1992).

Severity of agricultural injuries

Agricultural injuries vary in intensity from minor injuries, crushing injuries to amputations, and fatalities. The severity of injuries may vary with the type of machine involved. Injury severity descriptions also differ widely. ISS(Injury Severity Score) has been used by McElfresh and Bryan (1973), Cogbill and Busch (1985), Heeg, Duis and Klasen (1986). AIS (Abbreviated Injury Scale) has been used by Mohan and Patel (1992), Varghese and Mohan (1991) and Jansson and Jacobsson (1988). Others have used descriptive type of injury recording for severity (Calandruccio and Powers, 1949; Knapp, 1965; Howell and Smith, 1973; Simpson, 1984; Pickett et al., 1995). Others are based on fatalities only (Lawrence and Stephanson, 1955; Huston and Smith, 1969; Mcknight and Hetzel, 1985; Etherton et al., 1991).

The agricultural injuries were severe in nature as descried by different authors. The most frequent recorded injuries are fractures, lacerations and amputations (Calandruccio and Powers 1949, Knapp 1965, Howell and Smith 1973, Simpson 1984, Jannson and Jacobsson 1988). In PTO related injuries, fractures were 46% and 54% and soft tissue lesions which were 33% and 30% respectively in two studies (McElfresh and Bryan 1973, and Heeg, Duis and Klasen 1986). McElfresh and Bryan (1973) also showed that PTO injuries included traumatic amputations, multiple fractures and large skin avulsions including denudation of genitalia. Kalennak et. al. (1978) and Heeg, Duis and Klasen (1986) also described PTO injuries as serious and potentially fatal. Fracture of hands and lesions caused by PTO are recorded in a study by Kumar, Mohan and Mahajan (1998). Most of the tractor related studies (Table 2) are fatality based again indicating the menace of the problem. Trojani et al. (1998) reported posterior dislocation in power driven cultivation.

Agricultural injuries are severe but descriptive details of wounds have been given without ascribing standard injury severity codes. Comparisons of injury severity are not possible across different countries and studies in such cases

Injury prevention methods

The emphasis on prevention measures in studies were widely different. Active measures involve behavioural change through education, enforcement and supervision while passive measures are those which involve automatic safety devices, design modifications and retrofitting of existing equipment. Different authors have used different terminology for these prevention measures. Etherton et al. (1991) has used education, enforcement and engineering whereas Lundqvist and Gustafsson (1992) had suggested technical, human and organizational measures for injury prevntion.

Concept of man, machine and environment

In the 1950s and 1960s researchers working on the epidemiology of injuries shifted their emphasis from the "human error" approach to looking for multiple factors associated with injury. Haddon and Baker (1981) and their contemporary researchers showed that energy control could influence the incidence and severity of injury significantly. It is interesting that researchers working on paediatric and traffic injuries picked up this approach rather

quickly but those working on agricultural injuries continued to focus on the "human error" approach. It is possible that the latter were influenced by occupational health, where detailed data are usually not in the public domain and remain the property of the work site owners. This fact may have also influenced the tendency to blame the worker rather than taking a more detailed look at all the other factors involved.

Injuries were initially thought to result from a lack of knowledge and hence the victim was believed to be at fault. Earlier papers concluded that personal hazards were as a result of lack of knowledge and lack of training (Palmer, 1946; Young and Ghormley, 1946). Lawrence and Stephanson (1955) gave community based farm safety programs as a solution to injury prevention.

It was in the 1960s that safer design and passive protective measures were given more importance. Knapp (1965,1966) suggested that farm injuries occur because of exposure to an injury causing agent rather than carelessness or use of worn out equipment. He also indicated that a solution to the agricultural injury problem could be found by analyzing all associated factors including location, worker's status and cause of injury. Rees (1965) analysed the tractor injury problem taking into consideration factors related to driver, environment and the vehicle. He recommended that safer frames should be provided on tractors to prevent overturn injuries.

Muckala (1967) used the concept of agent, host and environment to approach the injury problem at a local level. Smithurst (1968) covered both passive and active measures: and suggested improved design, not allowing passengers on tractors and not allowing children to drive or play on tractors. Huston and Smith (1969) included engineering and ergonomic aspects of the problem. They pointed out that investigation of the causes and circumstances of injury could be effectively used for prevention purposes. Karlson and Noren (1979) promoted voluntary standards, including: power-take off fitted with shields, which can not be circumvented; and the installation of roll over protection structures on all tractors.

Simpson (1984) emphasized automatic protection measures. Active prevention measures like education, mass communication, job safety analysis, training, supervision, enforcement, along with passive measures, are also suggested (Jansson and Jacaobsson, 1988; Etherton et al., 1991).

Tractor injury prevention

The most prevalent mechanism of tractor injuries in HICs are rollovers, thus rollover protection is studied in depth. Rollovers may result from misjudging slopes (Owen and Hunter, 1983; Murphy, Bepper and Sommer, 1985). Slope and stability indicators are suggested for the prevention of overturning incidents. Kelsey and Jenkins (1991) and MMWR (1993) propose roll over protection structures retrofits for existing tractors.

A detailed study of 76 tractor related injury cases from India shows that usage pattern changes the injury causing mechanism, as roll over injuries form a small percentage of the total injuries reported (Kumar, Mohan and Mahajan, 1998). This is in variance with

the experience of farmers in Europe, North America and Australia. The reason for this variation is not clear, as the difference in circumstances is not apparent from the published literature. However, it appears that misjudging slopes may not be the only factor involved as tractor use in India also involve operation on slopes. It is possible that tractors with more powerful engines in the HICs result in higher operating speeds that could thus be a contributing factor.

Poor ergonomic design is also reported as a factor for tractor injuries, Suutarinen (1992) emphasized ergonomic improvements to overcome climbing in and climbing out of the cab, and hitching and unhitching of implement injuries.

In a study from China, Field and Gong (1980) suggested protective cabs for drivers and passengers. Since tractors are also used for transportation in LICs, Kumar, Mohan and Mahajan (1998) have emphasized the redesigning of tractor with trailers to allow for passenger safety. They also recommended redesigning of hitching mechanisms for trailers and implements to make hitching and unhitching safer and indicated that tractors should be made more conspicuous to prevent incidents at night. In an HIC study, Lehota, Marley and Melvis (1994) recommended "no extra riders" and discarding of tractors without roll over protection structures.

Prevention methods for the auxiliary source of power on tractors (power take off) include the use of shields or covers. Kalenak et al. (1978) suggested that "improved shields may reduce hazards but better safety practices would probably eliminate the majority of accidents".

Improvements for thresher and fodder cutting machines

In societies where large numbers of unsafe equipment are already in place, it is not possible to discard all the unsafe machines for economic reasons. Design solutions for safety must therefore consider retrofitting of existing machines with safety devices. This is important, otherwise the community may not accept safety campaigns.

Mohan and Patel (1992) in a study from Northern Indian rural area, suggest a change in the slope and dimensions of the thresher chute. Also a hand-warning roller has been placed to gives a tactile warning to the operator not to push further and protect the operator from flying objects from the threshing drum. For operators' safety, the chute should always be at elbow level so that in case of a jerk or loss of balance, torso weight will not push the hand into the drum causing amputation of the hand.

Suggestions for retrofitting for fodder cutting machines (Mohan and Patel 1992) include: a warning roller in front of the feed rollers on the chute, a flywheel locking pin, gear cover to prevent entangled, front safety guards on each blade.

Medical facilities

Along with prevention measures, many authors recommend effective medical care. Nolen (1963) described a doctor as a "skilled repairer" of injury and a chief catalyst for safety education among farmers. A decrease in pre hospital times can be an effective factor for

injury control as suggested by Knapp (1966) and Cogbill et al. (1985). Rivera reported that emergency medical systems with trained paramedics and recognized trauma centres improve the outcome of severely injured patients.

First aid measures for injuries on farms are inadequate and inappropriate. Varghese and Mohan (1990) reported that traditional methods are commonly used for agricultural injuries. Some of these prolonged the healing time of injuries well beyond the expected. They have suggested that irregular visits of city based doctors are not effective and emphasise that local medical practitioners and bone setters must be equipped with the knowledge to deal with trauma cases in a more effective manner.

Outcomes from interventions

Very few studies have reviewed the outcome of interventions. Springfeldt (1991) reported that in Finland, USA and Spain higher fatalities were because of low use of roll over protection structures on tractors and pointed out that in countries where mandatory regulations have been effective for many years the relative frequency of rollover fatalities has decreased. In Sweden the rollover fatalities have declined to 2% between 1959-89, as roll over protection structures regulation were implemented in 1959.

Mohan and Patel (1992) described their field experience of fodder cutting machine retrofitting. Because of their low cost (3-4 US dollars) and local manufacturing, they received a favourable response from the farmers as well as agricultural engineers. Over 100 fodder cutting machines and 54 sets of safer feeding thresher chutes made by local manufacturers and local technicians were introduced in field trials. These chutes also received a very favorable response from the user.

CONCLUSIONS

1. Agricultural injuries are serious problems in rural societies of both HICs and LICs. Farm injury patterns are severe in both but the machines causing injuries differ because mechanisation levels differ in different countries.

2. Outcomes of studies varied widely as population based studies gave different results from hospital based studies. The review also shows that there are very few community-based studies. Minor injuries are likely to be underreported in hospital studies as compared to population based health studies.

3. Children and old age group people constitute a significant proportion of the farm work force. Home and work place environments overlap in farming making children vulnerable to injuries. No serious attempt has been identified to include consideration of the presence of children and older people as a factor in safer design of farm machines.

4. Tractors have been found to cause serious injuries. However, in HICs these injuries result from rollovers while farming whereas in LICs these injuries result from the frequent use of tractors and trolleys for transportation.

5. Hand tool related injuries are a problem specifically seen commonly in the LICs.

6. Equipment operating at higher energy levels appears to be associated with incidence of more severe injuries. Such equipment needs more attention for incorporating safer design features.

7. Injury severity has not been scored uniformly in most studies. The severity of injuries and their outcomes cannot, therefore, be compared easily across countries. Priorities for injury prevention policies can not be planned logically based on these studies.

8. The majority of papers have focussed on behavioural modification of workers rather than finding design or environmental modifications for prevention of injuries. Whereas physical features such as overlapping of work and home environment in farming make safer design of the machine–enviornment system more important.

9. Effectiveness of different intervention have not been evaluated in most studies. This is important for further improvements in design of farming equipment.

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