Comprehension rates of safety pictorials affixed to agricultural machinery among Pennsylvania rural population

Comprehension rates of safety pictorials affixed to agricultural machinery among Pennsylvania rural population

ABSTRACT

Pictorials affixed to agricultural machinery are important tools to warn the user about the risks that can arise from the intended use or any foreseeable misuse of the machine; however, in the U.S. there is no legal requirement regarding the adoption of safety pictorials on agricultural machinery. This study investigated comprehension of safety pictorials in a sample of U.S. agricultural machinery users. Two hundred and eight Pennsylvanian participants were asked to indicate the meaning of 12 frequent safety pictorials by choosing one among 4 alternative labels. The results showed that pictorials referring to the most common risks in agriculture were not necessarily the best comprehended images, and two out of five participants have never seen the pictorials included in the study. Years of experience with the machinery enhanced comprehension, whereas 'part-time' farming and occasional use of machinery were related to poorer comprehension. Implications for operators' safety and solutions to improve pictorial noticeability and comprehension are discussed.

KEYWORDS: Agricultural machinery; Hazard communication; Pictorial comprehension; Occupational safety; Warning.

1. Introduction

Visuals have been used by humans to communicate since the earliest paintings were made on cave walls. The bridge between historical and modern pictorials is the social scientist Otto Neurath, who in 1925 created the Isotypes, a way to represent information by means of easily interpretable icons. From the beginning, Neurath's pictorials have been used to communicate information about the working environment, such as production process, emigration, mortality and unemployment. A contemporary successful example form of visual communication are the emoticons, which were created in 1982 by scientist Scott Falham. Thanks to pervasive mobile communication devices, emoticons are today universally and globally adopted (see Holmes, 2013, for a short but complete review of non-verbal symbols' evolution).

Modern pictorials are used and have been investigated in many different domains, such as pharmaceuticals, heavy industry, transport and consumer goods (Barros et al., 2014; Boelhouwer et al., 2013; Erdinc, 2010; Ng and Chan, 2008). Typically, pictorials are used to convey safety information, since they can quickly communicate concepts and instructions and can be better remembered than words (Laughery and Wogalter, 2014; Wogalter et al., 2006). Since a pictorial is supposed to be immediately comprehended by everyone without any associated words and without any specific education (Adams et al., 2010), different standards have been developed (e.g., those from the ANSI Z535 Committee on Safety Signs and Colors) to promote the adoption and use of uniform and effective symbols for safety communication, providing some procedures for evaluating image effectiveness in communicating the intended message, together with considerations for graphic design (ISO-7010:2011; ANSI Z535.3-2011). Despite all these efforts, different studies have reported that many pictorials currently in use are poorly understood (Chan and Ng, 2010a; Duarte et al., 2014; Liu et al., 2005; Rubbiani, 2010). Furthermore, inconsistent results are reported in the literature about the role played by socio-demographic variables and previous experience (i.e., familiarity) with the

pictorials in affecting users' comprehension rates (for instance, see Lesch, 2003, and Ng and Chan, 2008 for age; Ng and Chan, 2011, and Hancock et al., 2004 for familiarity with the symbols).

Warning users against potential hazards is an even more relevant issue in agriculture, as this is one of the three most hazardous sectors in developing and industrialized countries (ILO, 2014). Kumar and Dewangan (2009) reported 6.39 accident per 1000 workers/year in north eastern India; Kogler et al. (2015) reported that in the year 2013, 3,805 accidents occurred in the entire agricultural sector in Austria, and 56 of them were fatal; Fabiano et al. (1995) in their analysis of accidents in the Italian industry in the century 1890-1989, highlighted that despite the considerable variations of economic and social conditions and the increasing technological and scientific improvement, the number of accidents never dropped below 110 cases per 1000 workers/year, with agriculture being the most critical sector. For the U.S., the fatal work injury rate for the agriculture, forestry, fishing and hunting sector was 24.9 (per 100,000 full-time equivalent workers) in 2014, whereas the fatality rate for all the occupational sectors in the same year was 3.3 (NIOSH, 2016; U.S. Department of Labor 2016a, 2016b).

Agriculture involves the use of a wide variety of hazardous equipment and instruments engendering many risks for the users, and machinery is, indeed, the major source of injury (Jawa et al., 2013). In the study by Kumar and Dewangan (2009), farm implement-related accidents accounted for 40% of the accidents, and Kogler et al. (2015) noted that in the period 2008-2010, 59% out of 3.250 accidents in Austria were caused by machinery.

The most hazardous machinery in agriculture is the tractor (Jawa et al., 2013) and the most serious accidents are due to overturn or rollover. An important role in reducing the likelihood of tractor operators from being crushed in such events is the adoption of Roll-over Protective Structure (ROPS) (Cavallo et al., 2014; Murphy et al., 2010). The U.S.

Occupational Safety and Health Act (OSHA) requires approved ROPS to be present on agricultural tractors over 20 horsepower (15 kW) manufactured after October 25, 1976, when operated by hired employees (Murphy, 2014). OSHA regulations cannot be enforced on farms with fewer than 11 employees, and a farm operator who has no employees is not affected at all by any OSHA regulation. This legally allows employers and other farm operators in U.S. to avoid the use of ROPS on a large number of tractors.

Other machinery such as harrows, seeding equipment, harvesters, mowers, wagons, trailers, manure spreaders, and elevating equipment are reported as hazardous and associated with high rates of injuries and deaths in the sector (ILO, 2011). The principal safety hazards related to these machineries are cutters, gears, belts, shafts and other moving parts, burst hydraulic hoses and live electrical equipment, which may cause cuts, burns, electrocution, fractures and amputations. Such injuries occur both during the course of production and also during maintenance and repairs, cleaning, clearing blockages, etc. (ILO, 2011; Kumar and Dewangan, 2009; Narasimhan et al., 2010).

To promote users' safety and health, the International Labour Organization (ILO, 2011) recommends the use of safety pictorials on agricultural machinery to warn the user about the risks that can arise from the intended use or any foreseeable misuse of the machine, allowing the user to adopt protective measures and safety behaviours (ISO 14121-1:2007). The International Organization for Standardization establishes some principles for the design and application of these safety pictorials. The standard dealing with the topic is the ISO 11684:1995. It was developed based on ASAE S441.3 and since 2011, has been adopted as ANSI/ASABE AD11684:1995 (Apr 2011) by the American National Standard Institute (ANSI) and the American Society of Agricultural and Biological Engineers (ASABE), replacing the previous standard. In the U.S. there is no legal or mandatory requirement by state or federal government about the adoption of warning pictorials on agricultural

machinery. However, the compliance to ISO and other industry safety standards is considered de facto as the manufacturer's 'minimum obligation', although product compliance with safety standards does not prevent an injured person from suing a manufacturer in the civil court system.

The existing lack of mandatory safety pictorial adoption in the U.S. makes its rural population –and that of Pennsylvania in particular, as will be discussed in the next paragraph- a relevant context in which to investigate the familiarity with and the comprehension of these safety symbols.

1.1 U.S. and Pennsylvania: agricultural system, machinery and safety issues

The U.S. is one of the major players in global agricultural business (FAO, 2015). In 2014, 17.3 million full- and part-time jobs were related to agriculture and related industries, corresponding to approximately 9.3% of total U.S. employment (USDA ERS, 2016). Every day, hundreds of U.S. agricultural workers suffer a serious lost-time injury (NIOSH, 2015), and according to statistics, 5% of these injuries result in permanent impairment (U.S. Department of Labor, 2016a). Deaths and injuries among the agriculture workforce have important economic consequences, such as medical costs and lost productivity and earnings; the cost of agricultural occupational injuries has been estimated to exceed $4 billion in direct and indirect costs (NIOSH, 2011). Furthermore, fatal accidents in family owned farms, representing 97% of the U.S. farms (USDA, 2015), frequently lead the farms to halt operations and the survivors to leave the farms (Kelsey, 1991).

Within the U.S., agriculture represents a major industry in Pennsylvania. Indeed, Pennsylvania ranks first in mushrooms production, fourth in dairy, apple and grape production and horticulture retail sales, and seventh in winemaking (USDA, 2014a).
The main data about farming systems, farm demographics and farm accidents in the U.S. and Pennsylvania is presented in Table 1. As can be observed, the Pennsylvanian local farming

system and rural population is a suitable representation of U.S. agriculture. Moreover, the main causes of accidents are similar for both U.S. and Pennsylvania, and in addition, the ratio between the number of deaths and the total number of operators is even higher in Pennsylvania than in the U.S. (0.0024 vs. 0.0018).

[Table 1 near here]

Based on these considerations, this study investigated the comprehension of safety pictorials affixed to agricultural machinery in a sample of Pennsylvania users. The aims were:

(1) to investigate comprehension rates of different pictorials and identify the most comprehended and the most critical (less comprehended) ones;
(2) to explore the familiarity (i.e., prior experience with a warning or a product; for a review, see Rogers et al., 2000) of the users with the safety pictorials;
(3) to evaluate which variables influence pictorials' comprehension, considering socio-demographic variables (education, age) and variables regarding participants' expertise (occupation, farm size, frequency of machinery use, years of experience with machinery).

2. Method

2.1 Participants

The study was conducted interviewing visitors attending the 2014 edition of the 'Ag Progress Days', from August 12th to 14th. The 'Ag Progress Days' is Pennsylvania's largest outdoor agricultural exposition and features the latest technology and research exhibits, educational programs, and guided tours. The event is held at the Russel E. Larson Agricultural Research Center in Rock Spring, 15 km (9 miles) southwest of State College (PA), and it is sponsored by Penn State College of Agricultural Sciences. In 2014, according to the post-event figures (Penn State College of Agricultural Sciences, 2015), there were over 400

exhibitors from 34 states and 4 provinces of Canada and 42,000 attendees, over 60% of which were actively engaged in agriculture or related professions.

Similar to previous studies (Caffaro and Cavallo, 2015; Görücü, et al., 2014; Reichardt and Jürgens, 2009), we decided to take advantage of this high confluence of rural population in a single place to carry out the present research, as it is very hard to involve individuals from the agricultural population in face-to-face surveys, given they are spread across the country and have different paces of work.

The participants to the survey were asked to complete a paper-and-pencil questionnaire. The survey involved 245 individuals randomly selected during exhibition opening hours.

2.2 Instrument

An adapted version of the questionnaire used by Caffaro and Cavallo (2015) and Caffaro, Mirisola et al. (2017) was administered in the present study. The questionnaire entails twelve pictorials from ISO 11684:1995 relating to the most serious risks in agriculture (ILO, 2011; Kumar and Dewangan, 2009; Narasimhan et al., 2010) (electrical hazards: Pictorial #5; crushing hazards: #1, #7, #12; cutting hazards: #4; entanglement hazards: #3, #6; stability hazards: #9, #11; maintenance hazards: #2, #8, #10). The pictorials were presented to the participants in a two-pictorial-panel format with a safety-alert symbol above and the hazard avoidance pictorial below. The participants in the survey had to select the most appropriate verbal description from among four choices to describe the meaning of each of the 12 pictorials included in the questionnaire. For each pictorial adopted for the study, there was a correct answer, a partially correct answer and two incorrect answers (see Chan and Ng, 2010a, 2010b). Moreover, for each of the pictorials, the participants had to report whether they had already seen it (three alternatives: never, sometimes, often). Finally, the questionnaire included a section to collect some relevant socio-demographic information:

gender, age, state or county of origin, occupation, education, frequency of use of agricultural machinery, years of experience with agricultural machinery, type of machinery used, and the size of the farm where they usually work.

For each pictorial, correct answers were the description of the pictorial available in the ISO standard 11684:1995; the partially correct answers referred to an avoidance behaviour in relation to a partial identification of the hazard represented by the pictorial; incorrect answers referred to an avoidance behaviour which was not in relation to the specific hazard. The partially correct and incorrect answers were created as described in Caffaro and Cavallo (2015). These answers were also reviewed and approved by Penn State farm safety experts for use in Pennsylvania (the questionnaire used in the present study is reported in Appendix A).

2.3 Procedure

Participants were recruited from among the visitors of the exhibition. Trained research assistants handed out the questionnaire to people walking through the exhibition. The assistants explained the aims of the study and informed the participants that the questionnaire was anonymous. Pictorials were presented in a randomized order to each of the participants in the survey. Completion of the questionnaire took approximately 8 minutes. No incentive was offered to induce visitors to participate in the survey.

2.4 Data analyses

Data analyses involved three steps. First, for each pictorial included in the questionnaire, a comprehension score was calculated by following the dichotomous scoring procedure recommended in the ANSI Z535:2011 standard, i.e., scoring incorrect and missing answers as 0, and partially correct and correct answers as 1. Then, non-parametric Chi-squared tests were computed to assess whether the percentages of correct answers were not significantly inferior than the recommended comprehension rate of 85% or over (ISO 7010:2011; ANSI Z535.3:2011).

Second, to assess whether the comprehension rates of pictorials were related to the familiarity with each of them, Spearman rank correlations were computed.

Third, to determine the possible effects of some user characteristics on the comprehension performance, for each participant a mean comprehension score was computed by considering the correctness of the answers to the safety pictorials that were recognized at an acceptable level (recognition score not significantly inferior to 85%). By considering this mean comprehension score as dependent variable, an ANCOVA was computed with education, occupation, frequency of machinery use, and farm size as factors, and age and years of experience as covariates.

3. Results

3.1 Participants' sociodemographic characteristics

Approximately 300 persons were addressed and 245 persons completed the questionnaire. Of these, 8 were excluded because they had too much missing data, and 29 because they were not actual users of agricultural machinery. The final sample consisted of 208 individuals. Almost all participants came from Pennsylvania (92.7%), the rest from other U.S. states (7.3%). Agricultural machinery is regularly used by 73.6% of the participants, while 26.4% sometimes used it. The most common agricultural machine, used by almost all participants (99.5%), was the tractor. The participants' mean duration of experience with agricultural machinery was 27.9 years (*SD* = 17.6). The main characteristics of the participants are presented in Table 2.

[Table 2 near here]

3.2 Comprehension of the 12 pictorials and their familiarity

The percentages of completely correct, partially correct, and incorrect answers, as well as the sum of completely and partially correct answers for the 12 safety pictorials are reported in Table 3. Non-parametric Chi-squared tests showed that the percentages of completely

correct answers were all significantly inferior than the minimum recommended comprehension rate of 85% (ISO-7010:2011; ANSI Z535.3-2011). Moreover, there is a huge variability among pictorials, the percentage of completely correct answers ranging from a minimum of 26.9% for pictorial #1 to a maximum of 78.4% for pictorial #9. When considering the sum of correct and partially correct answers, 5 out of 12 pictorials reached a percentage that is not significantly inferior than 85% (pictorials #2, #3, #4, #9, #11).

[Table 3 near here]

These comprehension rates seem not to be related to the familiarity with the pictorials studied (Table 4). In particular, the percentage of participants who have never seen a given pictorial ranged from a minimum of 21.6% for pictorial #6, a pictorial which showed a rather high percentage of incorrect answers (42.3%, Table 3), to a maximum of 58.7% for pictorial #7, which showed a rather low percentage of incorrect answers (22.1%). In fact, a Spearman's rank correlation showed that there was no significant relation between the familiarity with the pictograms and the comprehension rates ($r_s(12) = -.123$, $p = .582$). Moreover, on average, approximately 40% of the participants have never seen the pictorials included in the study.

[Table 4 near here]

3.3 Effects of user characteristics on comprehension performance

To determine the possible effects of some user characteristics on the comprehension performance, an ANCOVA was computed on the mean comprehension score obtained by each participant for the 5 pictograms that were recognized at an acceptable level (recognition rate not significantly inferior than 85%), by considering education, occupation, frequency of machinery use, and farm size as factors, and age and years of experience as covariates. The results showed a significant effect of years of experience, $F(1, 181) = 3,92$, $p < .05$, $\eta p^2 = .021$, and an interaction between occupation and frequency of machinery use, $F(3, 181) = 3,13$, $p < .05$, $\eta p^2 = .049$. In more detail, the longer the experience with agricultural

machinery, the higher the comprehension score, (β = .003, $t(207) = 1.98$, $p < .05$). Regarding the interaction between occupation and frequency of machinery use, univariate statistics revealed that part-time farmers who use agricultural machinery from time to time (*EMM* = 0.787, *ESD* = 0.068) had significantly inferior comprehension scores than the ones who use machinery regularly (*EMM* = 0.982, *ESD* = 0.067); the frequency of machinery use had no effect on the comprehension scores for the other three types of agricultural operators.

4. Discussion

This study investigated the comprehension of safety pictorials affixed to agricultural machinery in a sample of U.S. users. The ISO standard for safety signs (ISO 7010:2011) and the ANSI standard Z535.3 (2011) both require a symbol to reach a level of over 85% correct answers in an open-ended comprehension test to be considered acceptable. Similar to Davies et al. (1998), we adopted the 85% threshold of correct answers as a general guideline to examine the results of the pictorials' comprehension. Under this criterion, only 5 of the 12 pictorials investigated obtained a satisfactory comprehension rate. In addition, the participants' comprehension performance presented a high variability between pictorials, supporting the idea that users comprehend the safety pictorials to some extent, but none have a complete and exhaustive knowledge of them.

The most comprehended pictorials were #4 and #9. Regarding pictorial #4 - referring to the risk of cutting or severing feet with moving knives when operating-, the Pennsylvanian agricultural system is mostly geared towards forage crops for animal feeding (USDA, 2014a, 2014b), where most of the farm tasks are carried out by machinery equipped with rotating knives/tools such as disc mowers, mower-conditioners and flail choppers for the fields, or feed mixer wagons in the animal raising facilities. Thus, the risk of being injured in the upper and lower limbs, or even worse, of being caught or pulled and killed by these tools, is well known among machine users in this area.

Regarding pictorial #9 referring to the need to lock ROPS in upright position, over the years, different approaches and strategies for increasing the number of ROPS on tractors in use in Pennsylvania have been adopted: educational programs, incentives for ROPS retrofitting or scrapping older farm tractors without ROPS, social marketing, and enacting state or national regulations that require tractors to be equipped with ROPS. All these actions have made farmers widely aware of the protection ensured by ROPS, and the popularity of ROPS on farm tractors has consistently increased up to 59% in 2006. This percentage, however, is not considered sufficient to reduce the overturn fatalities nearly to zero (Murphy et al., 2010).

The third most comprehended pictorial was #2, referring to the need to consult the operator's manual before performing maintenance activities on the machine. It is encouraging that this important pictorial was well comprehended, since almost 18% of injuries occur while performing maintenance and repair work (Narashiman et al., 2010). However, it has to be taken into account that the automotive literature shows that operator's manuals are infrequently or incompletely read by consumers (Mehlenbacher et al., 2002) due to the excessive information content, the confusing visuals and safety icons used, and the poor document design (Tebeaux, 2010). Thus, some changes in the design of the manuals should be made to encourage more frequent and complete reading. A way to make user manuals easier to read and follow – thus enhancing the relevance and noticeability of reported safety information - could be to transfer them into some digital devices. Currently, digitalisation is of broad interest in our society, with many applications in different life domains. Technological interfaces could also be adopted for safety issues (Reinert, 2016); user manual layouts could be rearranged to fit into some apps for mobile phones or other multimodal interfaces and interactive devices on agricultural machines to improve users' attention towards as well as comprehension of safety information (Kohanbash et al., 2012).

Another well-comprehended pictorial was #11, referring to the risk of tractor roll-over on steep slopes. Roll-over is a well-known cause of death (Molari et al., 2014) and the high percentages of correct answers may be encouraging, suggesting that this pictorial leads to interpretations that may prevent hazardous behaviours. In addition, previous studies have shown that concreteness, meaningfulness and semantic closeness (Chan and Ng, 2010a, 2010b) of a pictorial may increase its comprehensibility. This could be the case of pictorial #11, as it is highly concrete, reporting the hazardous agent (the slope) and the effects of driving on it (machine is rolling-over).

The last pictorial with an adequate comprehension rate was #3, referring to the risk of entanglement in the Power Take-Off (PTO) drive shaft. This result is encouraging since every tractor, which is the most commonly used agricultural machine (Iftikhar and Pedersen, 2011), is equipped with a PTO, and PTO drive shaft safe operation is one of the main topics in farm-machinery health and safety promotion campaigns (Thomas and Buckmaster, 2003).

Besides these 5 pictorials, for 7 out of 12 pictorials, the comprehension rates could not be considered as sufficient. These 7 pictorials referred to a variety of risks operators are exposed to: crushing, entanglement and electrical risks, and maintenance-related risks.

The pictorial showing the lowest comprehension rates was #1. The reason for this low rate may be that this pictorial is specific to some types of machines, namely those with lifting hydraulic cylinders, thus the users may not be familiar with it (actually 39.4% declared never having seen one). On the other hand, considering the pictorial characteristics that may affect comprehension (Liu and Ho, 2012), the design of the specific pictorial presents some criticalities in terms of meaningfulness or semantic distance (Chan and Chan, 2013); the presence of the harrow may focus attention on the direction of the movement of the cylinder rather than on the need to secure it.

The low comprehension rate of pictorial #6 is rather surprising, if we consider the high comprehension rate of pictorial #3, which also refers to a PTO-related hazard, and the fact that tractors are the most commonly used agricultural machine (Iftikhar and Pedersen, 2011), and each tractor is equipped with a PTO. Therefore, users have many occasions to encounter this pictorial while working, and indeed, over 77% of the participants reported having already seen it. The present result may be interpreted by considering what is reported by Rogers et al. (2000), "users might not comprehend the significance of the warning if prior experience with the product has been benign" (p.122). That is, if farmers usually operate a PTO without being involved in accidents and injuries, it is possible that they do not pay attention to the pictorial referring PTO shaft-related risk, do not ask themselves about its meaning and simply ignore it because they think they know how to operate PTO shafts safely. The same interpretation may be used for the low comprehension rates of pictorials #5 and #8, warning against electrocution and incorrect maintenance procedure. However, these results deserve further investigation in future studies.

The low comprehension rates for pictorials #7, #10 and #12 may result from design deficiencies. Regarding pictorial #7, neither the number of people represented in the pictorial nor the way they are positioned are clear, raising questions such as, "Is it showing one person in two positions or two people?"; "What activity is being performed?"; or "What is the person on the right doing?". With regard to pictorial #10, its meaningfulness and semantic distance may be critical, the pictorial intends to inform the user about the need to *read and understand* the warning notes printed in the user manual, but in the pictorial, these actions are not represented. Finally, pictorial #12 may lack in concreteness and semantic depiction; based on what elements should we understand that it represents a wheel?

The possible interpretation of the present results raises some considerations about the need to further investigate the role played by pictorial characteristics in affecting

comprehension of safety pictorials affixed to agricultural-machinery, as it has already been done in other sectors (Chan and Ng, 2010a; Ng and Chan, 2008). Identified critical aspects may benefit from some re-design interventions (Edworthy et al., 2004), including also the opportunity to combine the graphical sign with some textual keywords, to improve the comprehension of complex hazards (Wogalter et al., 2006).

With regard to the variables affecting pictorials' comprehension, comprehension increased with increasing years of experience with agricultural machinery. This result is consistent with the one reported by Caffaro and Cavallo (2015) from a similar investigation among Italian users, and it may be interpreted by considering that by developing familiarity with the machine through routine upkeep and inspection, the operator can increase his/her knowledge of the potential safety hazards and related pictorials (Rogers et al., 2000).

The results about the role played by experience with machinery in enhancing comprehension may raise some considerations about the need for training interventions to explain pictorials' relevance and meaning to those who are inexperienced in the use of agricultural machinery and who thus may be at higher risk. Regarding training methods, Chan and Ng (2010b) proved the effectiveness of a recall training, in which participants are first notified about the meaning of the targeted symbols and then have to orally recall the meaning of randomly selected symbols.

This same suggestion may also come when considering the results about the poorer comprehension performance of part-time farmers occasionally using machinery. These kinds of operators represent an important part of the U.S. agricultural population. Figures from the 2012 U.S. Agricultural Census depict the dimensions of the part-time farming; the farm is the place of residence for three fourths of the farmers, but the farm does not provide the majority of their household income, as 57% of these farms had less than 25% of household income deriving from their farm; 52% of the farm households had a primary occupation other than

farming; and 40% of the principal operators worked off the farm for 200 or more days per year (USDA, 2014c).

Part-time workers are especially employed in agriculture worldwide (Lien et al., 2006), following the general trend of the last 20 years of significant growth in labour governed by casual, part-time, subcontract or franchised arrangements, virtually in all OECD countries and throughout different sectors (Ferrie et al., 1999). The results of international research show that precarious labour is associated with increased fatalities, occupational injuries, and illness in various industry sectors across a number of countries (Caffaro et al., 2017; Fabiano et al., 2008). Fabiano et al. (2008), in their study on temporary work involving different industrial sectors, interpret this incidence as being due to a lack of experience in the activity, to insufficient specific knowledge (formal and informal) about the specific machines and tools to be used, and to inadequate training periods in temporary workers. Possible methods to be adopted to promote safety may include diffusion of information on regulatory provisions, management training in safety, enhancement of specific training, and formation targeted to personnel hired through staffing agencies, as well as implementation of health and safety regulations for temporary workers. Similar considerations may apply to part-time workers in agriculture, who may need specific training interventions to increase their comprehension of safety pictorials when dealing with hazardous machinery.

This study presents some limitations that must be taken into account.

The survey was carried out in the state of Pennsylvania. Studies regarding a local area involve participants with a similar cultural background and thus can provide more comparable data (Smith-Jackson et al., 2010). However, in the future, it would be useful to extend the study to additional areas of the U.S. to obtain more generalizable results.

With regard to the sample, two considerations should be made. The first is in relation to the very limited participation of women, which did not allow to analyse the gender effect.

Since the participation of women in the agricultural sector is increasing (de Schutter, 2013), a balanced design should be adopted in future similar studies to investigate the issue. The second deals with the educational level of the participants of the study: over 40% of the interviewees obtained a university degree. Statistics of the United States Department of Agriculture report high school graduation to be the highest educational attainment for almost 42% of farm operators, whereas 25% attended some college and 24% completed college (USDA, 2007, as reported in Hoppe et al., 2010). Thus, our sample seems to be more educated than the average population of U.S. farm operators. Although previous studies found no effects of education either on the comprehension rates of safety pictorials (Rubbiani, 2010) or on the occurrence on injuries (Narasimhan et al., 2010), the role played by education should be investigated more in detail by considering populations with low or limited literacy as well.

Another limitation of the study arises from the limited number of pictorials investigated. We considered 12 pictorials, referring to frequent risks involving agricultural machinery; however, it should be noticed that the ISO 11684:1995 standard provides over one hundred examples of pictorials describing machinery-related hazards in over 10 categories (e.g., entanglement hazards, cutting hazards); therefore, other pictorials could be considered in future investigations to widen the results of the present study. Furthermore, data regarding previous exposure to the pictorials was solely based on self-reports. The effects of this variable could be better investigated in future research by means of an experimental design in which pictorials' comprehension would be tested by exposing different groups of participants to pictorials for a different length and number of times, to gather information about the effectiveness of exposure in enhancing pictorials' comprehension.

Finally, in a possible development of the research, it may be useful to also assess the history of previous accidents incurred by the participants (Narashiman et al., 2010) to further

investigate the relationship between experience and pictorial comprehension, and how previous exposure to positive vs. negative outcomes in the use of machinery may enhance or hinder comprehension of safety pictorials.

5. Conclusions

The results of the present study indicate that only 5 out of 12 investigated pictorials yielded a comprehension level not significantly different from that of the 85% recommended in ISO and ANSI standards for a pictorial to be considered acceptable. The 7 pictorials which were poorly comprehended referred to different hazards, ranging from crushing to entanglement hazards or hazards related to maintenance activities. This low comprehension could be interpreted mainly in terms of pictorial design deficiencies. Further investigation is needed that specifically addresses the design of these pictorials, to identify those aspects which may benefit from a re-design intervention. With regard to the familiarity with the investigated pictorials, no clear patterns of relationship between familiarity and comprehension level were identified for the different pictorials, but overall, two out of five of the people participating in the survey declared having never seen the pictorials included in the study, thus not being familiar with them. Increasing familiarity with pictorials by means of focused training activities or a better placement of the pictorials on the machine and in the user manual, could make the pictorials more noticeable, memorable and better comprehended. Similar considerations may be applied to users' variables affecting comprehension, as previous experience with machinery enhanced pictorial comprehension, whereas being a part-time farmer using machinery occasionally was related to poorer comprehension performance. Part-time and unexperienced workers are especially exposed to the risk of accidents in different sectors and more information is needed about their own specific safety needs.

It should be noted that the present study gives only some insights into the comprehension of a few frequently used safety pictorials, and further research is urgently

needed on this topic. The expansion of this research area is also very relevant for agricultural machinery companies, as a low comprehension of safety pictorials may entail the risk of limitations of commerce in the multinational markets, given the safety regulations and standards included in international free trade agreements. Furthermore, more comprehensible pictorials overcome language barriers and enhance the communication of safety information to immigrant workers who may not correctly understand the local language.

Acknowledgements

The authors thank Mike Weber, Technical and Safety Services Manager at AEM (Association of Equipment Manufacturers) and Bill Harshman, Senior Project Associate at Penn State Extension Service, for their insight and expertise in the form of notes, commentaries and suggestions on documents to look at that greatly improved the manuscript, and Serap Görücü, research assistant, and Linda Fetzer, extension assistant, from the Penn State University for their important contribution in preparing and submitting the questionnaire.

References

Adams, A., Boersema, T., Mijksenaar, M., 2010. Warning symbology: Difficult concepts may be successfully depicted with two-part signs. *Information Design Journal,* 18(2), 94–106. https://doi.org/10.1075/idj.18.2.01ada

ANSI Z535.3:2011. *Criteria for safety symbols*. National Electrical Manufacturers Association, Washington, DC.

ANSI/ASABE AD11684:1995, Apr2011. 2011. *Tractors, machinery for agricultural and forestry, powered lawn and garden equipment - Safety signs and hazard pictorials - General principles.* American Society of Agricultural and Biological Engineers, St. Joseph, MI.

Barros, I.M., Alcântara, T.S., Mesquita, A.R., Santos, A.C.O., Paixão, F.P., Lyra, D.P., 2014. The use of pictograms in the health care: A literature review. *Res. Social Adm. Pharm.* 10(5), 704-719. http://dx.doi.org/10.1016/j.sapharm.2013.11.002

Boelhouwer, E., Davis, J., Franco-Watkins, A., Dorris, N., Lungu, C., 2013. Comprehension of hazard communication: effects of pictograms on safety data sheets and labels. *J. Safety Res.* 46, 145-155. http://dx.doi.org/10.1016/j.jsr.2013.06.001

Caffaro, F., Cavallo, E., 2015. Comprehension of Safety Pictograms Affixed to Agricultural Machinery: a Survey of Users. *J. Safety Res.* 55, 151-150. http://dx.doi.org/10.1016/j.jsr.2015.08.008

Caffaro, F., Mirisola, A., Cavallo, E., 2017. Safety signs on agricultural machinery: Pictorials do not always successfully convey their messages to target users. *Appl. Ergon*. 58, 156-166. http://dx.doi.org/10.1016/j.apergo.2016.06.003

Caffaro, F., Roccato, M., Micheletti Cremasco, M., Cavallo, E., 2017. Part-Time Farmers and Accidents with Agricultural Machinery: A Moderated Mediated Model on the Role Played by Frequency of Use and Unsafe Beliefs. *J. Occup. Health*. http://dx.doi.org/10.1539/joh.17-0061-BR. [Epub ahead of print]

Cavallo, E., Langle, T., Bueno, D., Tsukamoto, S., Görücü, S., Murphy, D.J., 2014. Rollover protective structure (ROPS) retrofitting on agricultural tractors: goals and approaches in different countries. *J. Agromedicine* 19(2), 208–209. http://dx.doi.org/10.1080/1059924X.2014.889621

Chan, A.H., Chan, K.W., 2013. Effects of prospective-user factors and sign design features on guessability of pharmaceutical pictograms. *Patient Educ. Couns.* 90(2), 268-275. http://dx.doi.org/10.1016/j.pec.2012.10.009

Chan, A.H.S., Ng A.W.Y., 2010a. Investigation of guessability of industrial safety signs: Effects of prospective-user factors and cognitive sign features. *Int. J. Ind. Ergonom.* 40(6), 689–697. http://dx.doi.org/10.1016/j.ergon. 2010.05.002.

Chan, A.H.S., Ng, A.W.Y., 2010b. Effects of sign characteristics and training methods on safety sign training effectiveness. *Ergonomics* 53(11), 1325-1346. http://dx.doi.org/10.1080/00140139.2010.524251

Davies, S., Haines, H., Norris, B., Wilson, J. R., 1998. Safety pictograms: are they getting the message across? *Appl. Ergon.* 29(1), 15-23. http://dx.doi.org/10.1016/S0003-6870(97)00021-5

de Schutter, O., 2013. *The agrarian transition and the 'feminization' of agriculture*. Conference Paper #37. Food Sovereignty: A Critical Dialogue. International Conference, Yale University, September 14-15.

Duarte, E., Rebelo, F., Teles, J., Wogalter, M. S., 2014. Safety sign comprehension by students, adult workers and disabled persons with cerebral palsy. *Safety Sci.* 62, 175-186. doi: http://dx.doi.org/10.1016/j.ssci.2013.08.007

Edworthy, J., Hellier, E., Morley, N., Grey, C., Aldrich, K., Lee, A., 2004. Linguistic and location effects in compliance with pesticide warning labels for amateur and professional users. *Hum. Factors* 46(1), 11-31. http://dx.doi.org/10.1518/hfes.46.1.11.30383.

Erdinc, O., 2010. Comprehension and hazard communication of three pictorial symbols designed for flight manual warnings. *Safety Sci.* 48(4), 478-481. http://dx.doi.org/10.1016/j.ssci.2009.12.019

Fabiano, B., Parentini, I., Ferraiolo, A., Pastorino, R., 1995. A century of accidents in the Italian industry: Relationship with the production cycle. *Safety Sci.* 95, 65-74. http://dx.doi.org/10.1016/0925-7535(95)00043-7

Fabiano, B., Currò, F., Reverberi, A.P., Pastorino, R., 2008. A statistical study on temporary work and occupational accidents: specific risk factors and risk management strategies. *Safety Sci.* 46(3), 535-544. http://dx.doi.org/10.1016/j.ssci.2007.05.004

FAO (Food and Agriculture Organization of the United Nations), 2015. *FAO Statistical Pocketbook 2015*. Food and Agriculture Organization of the United Nations, Rome. ISBN 978-92-5-108802-9

Ferrie, J., Marmot, M., Griffiths, J., Ziglio, E., 1999. Labour Market Changes and Job Insecurity: A Challenge for Social Welfare and Health Promotion. Regional Office for Europe of the World Health organization, Denmark.

Görücü, S., Cavallo, E., Murphy, D.J., 2014. Perceptions of Tilt Angles of an Agricultural Tractor. *J. Agromedicine* 19(1), 5-14. http://dx.doi.org/10.1080/1059924X.2013.855690

Görücü, S., Harshman, W., Murphy, D.J., 2015. *Pennsylvania Farm Fatalities during 2010-2014.* Penn State Extension. Available at http://extension.psu.edu/business/ag-safety/injury-data/injury-summaries (Accessed January 2016)

Hancock, H.E., Rogers, W.A., Schroeder, D., Fisk, A.D., 2004. Safety symbol comprehension: Effects of symbol type, familiarity, and age. *Hum. Factors* 46(2), 183-195. http://dx.doi.org/10.1518/hfes.46.2.183.37344

Holmes, N. 2013. World without words. *National Geographic USA*, 224(2), 20.

Hoppe, R.A., MacDonald, J.M., Korb, P., 2010. *Small farms in the United States: Persistence under pressure.* EIB-63, U.S. Department of Agriculture, Economic Research Service.

Iftikhar, N., Pedersen, T.B., 2011. Flexible exchange of farming device data. *Comput. Electron. Agric.* 75(1), 52-63. http://dx.doi.org/10.1016/j.compag.2010.09.010

ILO (International Labour Organization), 2011. *Safety and health in agriculture. ILO code of practice.* International Labour Office, Geneva. ISBN 978-92-2-124971-9

ILO (International Labour Organization), 2014. *Agriculture; plantations; other rural sectors.* Available at: http://www.ilo.org/global/industries-and-sectors/agriculture-plantations-other-rural-sectors/lang--en/index.htm (Accessed July 2014)

ISO 11684:1995. Tractors, machinery for agriculture and forestry, powered lawn and garden equipment — Safety signs and hazard pictorials — General principles. International Organization for Standardization, Geneva:

ISO 14121-1:2007. Safety of Machinery – Risk Assessment – Part 1: Principles. International Organization for Standardization, Geneva:

ISO 7010:2011. Graphical symbols - Safety colours and safety signs - Registered safety signs. International Organization for Standardization, Geneva.

Jawa, R.S., Young, D.H., Stothert, J.C., Yetter, D., Dumond, R., Shostrom, V.K., Cemaj, R., Rautiainen, R.H., Mercer, D.W., 2013. Farm machinery injuries: the 15-year experience at an urban joint trauma center system in a rural state. *J. Agromedicine* 18(2), 98-106. http://dx.doi.org/10.1080/1059924X.2013.766145

Kelsey, T.W., 1991. Fatal farm accident in New York: estimate of their costs. *Northeastern Journal of Agricultural and Economics* 20(2), 202-207.

Kogler, R., Quendler, E., Boxberger, J., 2015. Analysis of occupational accidents with agricultural machinery in the period 2008-2010 in Austria. *Safety Sci.* 72, 319-328. http://dx.doi.org/10.1016/j.ssci.2014.10.004

Kohanbash, D., Bergerman, M., Lewis, K. M., Moorehead, S. J., 2012. A safety architecture for autonomous agricultural vehicles. In: Proceedings of the American Society of Agricultural and Biological Engineers Annual International Meeting (paper number 121337110). ASABE, St Joseph, MI. https://www.ri.cmu.edu/pub_files/2012/7/ASABE%202012.Safety%20architecture.Rev08_FINAL.pdf

Kumar, G.V.P., Dewangan, K.N., 2009. Agricultural accidents in north eastern region of India. *Safety Sci.* 47, 199-205. http://dx.doi.org/10.1016/j.ssci.2008.03.007

Laughery, K.R., Wogalter, M.S., 2014. A three-stage model summarizes product warning and environmental sign research. *Safety Sci.*, *61*, 3-10. http://dx.doi.org/10.1016/j.ssci.2011.02.012

Lesch, M.F., 2003. Comprehension and memory for warning symbols: age-related differences and impact of training. *J. Safety Res.* 34(5), 495-505. http://dx.doi.org/10.1016/j.jsr.2003.05.003

Lien, G., Flaten, O., Jervell, A.M., Ebbesvik, M., Koesling, M., Valle, P.S., 2006. Management and risk characteristics of part-time and full-time farmers in Norway. *Appl. Econ. Perspect. Policy* 28(1), 111-131. http://dx.doi.org/10.1111/j.1467-9353.2006.00276.x

Liu, T., Zhong, M., Xing J., 2005. Industrial accidents: challenges for China's economic and social development. *Safety Sci.* 43(8), 503-522. http://dx.doi.org/10.1016/j.ssci.2005.08.012

Liu, Y.C., Ho, C.H., 2012. The effects of age on symbol comprehension in central rail hubs in Taiwan. *Appl. Ergon.* 43(6), 1016-1025. http://dx.doi.org/10.1016/j.apergo.2012.02.004

Mehlenbacher, B., Wogalter, M.S., Laughery, K.R., 2002. On the reading of product owner's manuals: Perceptions and product complexity. *Proc. Hum. Factors Ergon. Soc. Annu. Meet.*, 46(6), 730-734. http://dx.doi.org/10.1177/154193120204600610

Molari, G., Badodi, M., Guarnieri, A., Mattetti, M., 2014. Structural strength evaluation of driver's protective structures for self-propelled agricultural machines. *J. Agric. Saf. Health* 20(3), 165-174. http://dx.doi.org/10.13031/jash.20.10298

Murphy, D.J., 2014. Rollover Protection for Farm Tractor Operators. Penn State Extension. Available at http://extension.psu.edu/business/ag-safety/vehicles-and-machinery/tractor-safety/e42 (Accessed February 2016)

Murphy, D.J., Myers, J., McKenzie, E.A., Cavaletto, R., May. J., Sorensen, J., 2010. Tractors and Rollover Protection in the United States. *J. Agromedicine* 15(3), 249-263. http://dx.doi.org/10.1080/1059924X.2010.484309

Narasimhan, G.R., Peng, Y., Crowe, T.G., Hagel, L., Dosman, J., Pickett, W., 2010. Operational safety practices as determinants of machinery-related injury on Saskatchewan farms. *Accid. Anal. Prev.* 42(4), 1226-1231. http://dx.doi.org/10.1016/j.aap.2010.01.016

Ng, A.W., Chan, A.H., 2008. The effects of driver factors and sign design features on the comprehensibility of traffic signs. *J. Safety Res.* 39(3), 321-328. http://dx.doi.org/10.1016/j.jsr.2008.02.031

Ng, A.W., Chan, A.H., 2011. Investigation of the effectiveness of traffic sign training in terms of training methods and sign characteristics. *Traffic Inj. Prev.* 12(3), 283-295. http://dx.doi.org/10.1080/15389588.2011.556171

NIOSH (National Institute for Occupational Safety and Health), 2011. *NIOSH Centers for Agricultural Disease and Injury Research, Education and Prevention*. Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Available at https://eh.uc.edu/assets/uploads/2015/01/NIOSH_AgFF_Centers_Fact_Sheet_FINAL.pdf (Accessed January 2016)

NIOSH (National Institute for Occupational Safety and Health), 2015. *Analysis of the Current Population Survey.* Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National

Institute for Occupational Safety and Health. Unpublished (as quoted in http://www.cdc.gov/niosh/agforfish/sector.html#ref2, Accessed January 2016)

NIOSH (National Institute for Occupational Safety and Health), 2016. Agricultural safety. Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Available at http://www.cdc.gov/niosh/topics/aginjury (Accessed January 2016)

PennState College of Agricultural Sciences, 2015. *Ag Progress Days. Attendance figures.* Available at http://agsci.psu.edu/apd/about/attend_figures (accessed November 2016)

Penn State Extension, 2016. *Agricultural Safety and Health. Pennsylvania Farm Fatality Statistics And Summary Reports.* Penn State College of Agricultural Sciences. Available at http://extension.psu.edu/business/ag-safety/injury-data (Accessed February 2016)

Reichardt, M., Jürgens C., 2009. Adoption and future perspective of precision farming in Germany: results of several surveys among different agricultural target groups. *Precis. Agric.* 10(1), 73-94. http://dx.doi.org/10.1007/s11119-008-9101-1

Reinert, D., 2016. The future of OSH: a wealth of chances and risks. *Ind. Health*, 54(5), 387-388. DOI: 10.2486/indhealth.54-387

Rogers, W.A., Lamson N., Rousseau G.K., 2000. Warning research: An integrative perspective. *Hum. Factors* 42(1), 102-139. DOI:10.1518/001872000779656624

Rubbiani, M., 2010. Survey among agricultural workers about interpretation of plant protection product labels and safety data sheets. *Ann. Ist. Super. Sanità* 46(3), 323-329. http://dx.doi.org/10.1590/S0021-25712010000300017

Singh, S.P., Williamson H., 1981. Part-time farming: productivity and some implications of off-farm work by farmers. *Southern Journal of Agricultural Economics* 13(2), 61-67. https://doi.org/10.1017/S008130520002728X

Smith-Jackson, T., Wogalter, M.S., Quintela, Y., 2010. Safety climate and pesticide risk communication disparities in crop production by ethnicity. *Hum. Factors Ergon. Manuf.* 20(6), 511-525. http://dx.doi.org/10.1002/hfm.20208

Tebeaux, E., 2010. Safety warnings in tractor operation manuals, 1920-1980: Manuals and warnings do not always work. *J. Tech. Writ. Comm.* 40(1), 3-28. http://dx.doi.org/10.2190/TW.40.1.b

Thomas, R.S., Buckmaster, D.R., 2003. Relative Safety of Traditional Agricultural Tractor Power Take-Off (PTO) Drivelines Compared to Fluid Power - A Review. *J. Agric. Saf. Health* 9(3), 241-250. http://dx.doi.org/10.13031/2013.13689

U.S. Department of Labor,2016a. *Agricultural operations*. U.S. Department of Labor, Occupational Safety and Health Administration. Available at https://www.osha.gov/dsg/topics/agriculturaloperations (Accessed January 2016)

U.S. Department of Labor, 2016b. *Census of Fatal Occupational Injuries (CFOI) - Current and Revised Data.* U.S. Department of Labor, Bureau of Labor Statics. Available at http://www.bls.gov/iif/oshcfoi1.htm#charts (Accessed January 2016)

USDA (United States Department of Agriculture), 2011. *2011 Farm and Ranch Safety Survey*. United States Department of Agriculture. Available at http://usda.mannlib.cornell.edu/usda/current/FarmSafe/FarmSafe-05-30-2013.pdf (Accessed January 2016)

USDA (United States Department of Agriculture), 2014a. *2012 Census of agriculture. State profile Pennsylvania.* United States Department of Agriculture, National Agricultural Statistics Service. Available at http://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Pennsylvania/cp99042.pdf (Accessed February 2016)

USDA (United States Department of Agriculture), 2014b. *2012 Census of agriculture. United State. Summary and State data.* United States Department of Agriculture, National Agricultural Statistics Service, Volume 1, Geographic Area Series, Part 51, AC-12-A-51, Issued May 2014

USDA (United States Department of Agriculture), 2014c. *2012 Census of agriculture. Highlights. Farm demographics*. United States Department of Agriculture, National Agricultural Statistics Service. Document ACH12-3/May 2014. Available at http://www.agcensus.usda.gov/Publications/2012/Online_Resources/Highlights/Farm_Demographics/Highlights_Farm_Demographics.pdf (Accessed February 2016)

USDA (United States Department of Agriculture), 2015. *2012 Census of agriculture. Highlights. Family farms.* United States Department of Agriculture, National Agricultural Statistics Service. Document ACH12-26/March 2015. Available at http://www.agcensus.usda.gov/Publications/2012/Online_Resources/Highlights/NASS%20Family%20Farmer/Family_Farms_Highlights.pdf (Accessed February 2016)

USDA ERS (United States Department of Agriculture, Economic Research Service), 2016. *Ag and Food Sectors and the Economy.* The United States Department of Agriculture, Economic Research Service. Available at http://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/ag-and-food-sectors-and-the-economy.aspx (Last updated: Wednesday, February 17, 2016) (Accessed February 2016).

Wogalter, M.S., Silver N.C., Leonard S. D., Zaikina H., 2006. Warning symbols. In: Wogalter, M.S. (Ed.), *Handbook of Warnings*, 159-176. Lawrence Erlbaum Associates, Mahwah, NJ.

Table 1. Main farming and accidents statistics for the U.S. and Pennsylvania.

	U.S.	Pennsylvania
Overall farm land (ha)[a]	377.5 million	3.124 million
Number of farms[a]	2.08 million	58,800
Average farm size (ha)[a]	177	53
Farm sales >100,000$[a]	19.6%	20.7%
Number of all operators[b]	3.2 million	59,237
Gender of principal operator[b]	Male 86.33%	Male 85.73%
Farming primary occupation[b]	1.01 million	30,638
Average age of principal operator[b]	58.3	56.1
Average years on farm[b]	25.0	24.8
Accidents	568 deaths in 2014[c]	141 fatalities in 2010-2014[d]
Main cause of accidents	Tractors (36%)[e]	Tractors (44.4%)[f]

Note. [a] Source: USDA, 2015; [b] Source: USDA, 2014b; [c] Source: NIOSH,2016; [d] Source: Görücü et al., 2015; [e] Source: USDA 2011; [f] Source: Penn State Extension, 2016

Table 2. Characteristics of those involved.

Variables	Levels	*n*	%	*M*	*SD*
Gender	Males	188	90.9		
	Females	19	9.1		
Age				44.2	16.9
Occupation	Farmer	100	48.1		
	Farm worker	38	18.3		
	'Part time' farmer[a]	57	27.4		
	Other[b]	13	6.3		
Education	Middle school	17	8.2		
	High school	94	45.2		
	University degree	97	46.6		
Frequency of machinery use	Regular	253	73.6		
	Occasional	54	26.4		
Years of experience				27.9	17.6
Farm size	Small (up to 19 ha)	27	13.0		
	Middle (from 20 ha to 199 ha)	140	67.3		
	Large (200 ha or larger)	41	19.7		

Note. [a] 'Part time' farmers: those who do not have an official role in the agricultural industry but, in addition to their main occupation, spend time working in agriculture and using agricultural machinery (Singh & Williamson, 1981). [b]Other: includes persons who work with or are around agricultural machinery as they market them, repair them or offer technical assistance.

Table 3. Correct, partially correct, sum of completely and partially correct, and incorrect answers for the 12 safety pictorials studied.

Pictorial #	Completely correct[a] (%)	Partially correct (%)	Completely correct/ Partially correct (%)	Incorrect (%)
1	26.9	4.3	31.3	68.7
2	61.5	26.0	87.5[b]	12.5
3	48.6	32.2	80.8[b]	19.2
4	70.2	19.7	89.9[b]	10.1
5	48.6	20.7	69.2	30.8
6	53.4	4.3	57.7	42.3
7	33.2	44.7	77.9	22.1
8	64.9	5.8	70.7	29.3
9	78.4	11.5	89.9[b]	10.1
10	45.2	18.3	63.5	36.5
11	44.7	39.4	84.1[b]	15.9
12	42.8	15.4	58.2	41.8
Mean(SD)	51.53(15.00)	20.19(13.36)	61.21(15.02)	28.28(17.25)

Notes. [a]All percentages of completely correct answers are significantly less than 85% in non-parametric Chi-square tests. [b]Percentages are not significantly less than 85% in non-parametric Chi-square tests.

Table 4. Familiarity with the 12 pictorials studied.

Pictorial #	"Have you already seen this symbol?"(%)		
	Never	Sometimes	Often
1	39.4	44.2	16.3
2	32.2	42.3	26.0
3	51.9	38.0	10.1
4	42.3	46.2	11.5
5	39.4	48.6	12.0
6	21.6	43.3	34.1
7	58.7	35.1	6.3
8	53.8	38.5	7.7
9	45.7	41.8	12.5
10	36.1	49.0	14.9
11	24.0	56.3	19.7
12	47.1	43.8	8.7
Mean(SD)	41.02(11.40)	43.93(5.69)	18.98(8.14)

Appendix A.

Below you will find 12 safety pictorials that are usually found on different types of agricultural machinery.
For each pictorial, please choose the most suitable answer from the four alternatives. **You can only choose one answer.**
Even if you are not familiar with all of the pictorials it is important you answer as we are interested only in your interpretation of them.

THANK YOU FOR YOUR COOPERATION!

1		What do you think this pictorial means?[a] ATTENTION: □ Secure lifting cylinder with locking device before accessing hazardous area □ Insert locking device to prevent the lifting cylinder from falling □ Use lift arm supports during maintenance that requires lift arms to be raised □ Insert locking device on lifting cylinder by operating in the direction shown Have you ever seen this pictorial? □ never □ sometimes □ often
2		What do you think this pictorial means? ATTENTION: □ Consult Operator's Manual for proper service procedures □ Follow the maintenance procedures shown in the Operator's Manual □ Store Operator's Manual in a safe place □ Operator's manual is placed in the toolbox Have you ever seen this pictorial? □ never □ sometimes □ often
3		What do you think this pictorial means? ATTENTION: □ Check the direction of rotation and revolutions of the Power Take-Off before assembling the drive shaft □ Check the revolutions of the Power Take-Off before assembling the drive shaft □ Check the angle of rotation of the Power Take-Off before assembling the drive shaft □ Check that the Power Take-Off is working before assembling the drive shaft Have you ever seen this pictorial? □ never □ sometimes □ often
4		What do you think this pictorial means? ATTENTION: □ Do not place your feet under rotating knives □ Do not place your lower limbs close to moving units □ Keep your feet away from falling weights □ Do not rotate drive units by foot Have you ever seen this pictorial? □ never □ sometimes □ often

5

What do you think this pictorial means?

ATTENTION:
- Do not maneuver loader near electrical wires
- Loader bucket can become caught on electrical wires
- All electrical wires near the machine are energized
- Do not touch the metal parts of the machine because they are energized

Have you ever seen this pictorial?
 never sometimes often

6

What do you think this pictorial means?

ATTENTION:
- Do not work on input drivelines while engine is running
- Do not get close to the moving units while engine is running
- If you get caught do not touch the rotating driveline with your hands
- Ensure the driveline is securely attached at both ends

Have you ever seen this pictorial?
 never sometimes often

7

What do you think this pictorial means?

ATTENTION:
- Stay clear of the draft link lifting range while operating rockshaft controls
- Never stand behind the tractor while engine is running
- Do not stand behind the tractor to hitch/unhitch equipment
- Do not activate the lift if other persons are around

Have you ever seen this pictorial?
 never sometimes often

8

What do you think this pictorial means?

ATTENTION:
- Shut off engine and remove key before performing maintenance or repair work
- Disengage the power and stop the machine before servicing
- Read all instructions in the Operator's manual before starting the machine
- Shut off engine and remove key while waiting for technical assistance

Have you ever seen this pictorial?
 never sometimes often

9

What do you think this pictorial means?

ATTENTION:
- Always lock ROPS in upright position
- Lock ROPS in upright position when riding on slopes
- Foldable ROPS can accidentally deploy
- Raise the ROPS operating in the shown direction

Have you ever seen this pictorial?

 never sometimes often

10		What do you think this pictorial means? ATTENTION: □ Read Operator's Manual □ Operation manual must be with the machine at all times □ Consult machine spare parts catalogue □ Store the Operator's manual Have you ever seen this pictorial? □ never □ sometimes □ often
11		What do you think this pictorial means? ATTENTION: □ Do not drive where the vehicle may lose grip or balance □ Do not travel in a cross direction on a slope as it may cause the vehicle to roll over □ Should the vehicle roll over, do not jump out of the cab □ Do not turn uphill when operating on slopes Have you ever seen this pictorial? □ never □ sometimes □ often
12		What do you think this pictorial means? ATTENTION: □ Chock wheels to ensure the machine is secure □ Wedge chock blocks securely □ Ensure that vehicle park brake is engaged □ Chock wheels securely if jacking-up Have you ever seen this pictorial? □ never □ sometimes □ often

Note. [a] For the reader's convenience, the labels are reported in the following order per pictorial: the first answer is the correct answer, then the partially correct and the two incorrect labels follow.