

Preliminary results of a novel hay-hole fall prevention initiative

Erich K. Batra, MD, Brian W. Gross, BS, Shreya Jammula, BS, Eric H. Bradburn, DO, Ronald D. Baier, EMT-P, Michael J. Reihart, DO, Dennis Murphy, PhD, Kay Moyer, MS, Joseph Hess, PhD, Susan Lackmann, MD, Jo Ann Miller, MSN, and Frederick B. Rogers, MD, Lancaster, Pennsylvania

BACKGROUND:	Hay-hole falls are a prevalent source of trauma among Anabaptists—particularly Anabaptist youth. We sought to decrease hay-hole falls in South Central Pennsylvania through the development and distribution of all-weather hay-hole covers to members of the at-risk Anabaptist community.
METHODS:	Following the creation of a rural trauma prevention syndicate, hay-hole cover prototypes co-designed and endorsed by the Pennsylvania Amish Safety Committee were developed and distributed throughout South Central Pennsylvania. Preintervention and postintervention surveys were distributed to recipients to gain an understanding of the hay-hole fall problem in this population, to provide insight into the acceptance of the cover within the community, and to determine the efficacy of the cover in preventing falls.
RESULTS:	A total of 231 hay-hole covers were distributed throughout eight rural trauma-prone counties in Pennsylvania. According to preintervention survey data, 52% of cover recipients reported at least one hay-hole fall on their property, with 46% reporting multiple falls (median fall rate, 1.00 [1.00–2.00] hay-hole falls per respondent). The median self-reported distance from hay-hole to ground floor was 10.0 (8.00–12.0) feet, and the median number of hay-holes present on-property was 3.00 (2.00–4.00) per respondent. Post-intervention survey data found 98% compliance with hay-hole cover installation and no subsequent reported hay-hole falls.
CONCLUSION:	With the support of the Pennsylvania Amish Safety Committee, we developed a well-received hay-hole cover which could effectively reduce fall trauma across other rural communities in the United States. (<i>J Trauma Acute Care Surg.</i> 2018;84: 295–300. Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.)
LEVEL OF EVIDENCE:	Epidemiological study, Level III.
KEY WORDS:	Hay-hole; hay-hole fall; hay-hole cover; rural trauma.

According to the Centers for Disease Control and Prevention, agricultural occupations rank among the most hazardous professions in the United States, with significant rates of associated mortality and morbidity annually.¹ As rural youth are often recruited to assist with agricultural work, particularly on farms, injuries are prevalent within these individuals.² A 2014 report from the National Children's Center for Rural and Agricultural Health and Safety found an estimated 14,000 injuries afflicted rural youth in 2012.¹ One rural population particularly known for using the aid of their children are the Anabaptists, although limited research is available detailing the epidemiology of childhood injury in this community.

Home to nearly a quarter of the nation's Anabaptists,³ the Commonwealth of Pennsylvania is a major settling ground for this unique and diverse population. Collectively known as the Plain People, the most traditional Anabaptist sects include the Amish, Old Order Mennonite, and Brethren communities. Although represented in all but three Pennsylvania counties, the vast majority of Anabaptists reside in South Central Pennsylvania, particularly, Lancaster County, where nearly 30 unique Anabaptist groups from 412 congregations account for over 52,000 community members.^{3,4}

Leading simple lives devoid of many modern advances, such as electricity and automobiles, many Anabaptists live in church and family-oriented communities where they rely on farming to sustain their way of life. To cope with the demands that often coincide with agricultural occupations, many Anabaptist youth actively participate in work on the farm. From milking, to hay baling, these children are expected to complete a wide-array of potentially dangerous tasks, often placing them at increased risk for injury.^{5–8}

Upon review of registry data from Lancaster General Health/Penn Medicine and the Penn State Milton S. Hershey Medical Center, one particular farming injury was found to be a continuous problem for these at-risk children over the past 5 years: hay-hole falls. Specific to the two-story Pennsylvania forebay bank barn design that features an upper level for grain and hay storage above a dirt or concrete ground floor, hay-hole falls impose catastrophic personal and economic hardship for both those directly and indirectly affected. Used to transport hay and grain from the upper level of the barn 8 feet to 10 feet

Submitted: November 22, 2016, Revised: October 18, 2017, Accepted: November 9, 2017, Published online: December 1, 2017.

From the Trauma Services (B.W.G., S.J., E.H.B., R.D.B., J.A.M., F.B.R.), Lancaster General Health/Penn Medicine, Lancaster; Family and Community Medicine & Pediatrics (E.K.B.), Penn State Milton S. Hershey Medical Center, Hershey; Emergency Medicine (M.J.R.), Lancaster General Health/Penn Medicine, Lancaster; Department of Agricultural and Biological Engineering(D.M.), Pennsylvania State University, State College; Penn State Extension (K.M.), Pennsylvania State University, Lancaster; Penn State Hershey Children's Hospital (J.H.), Pediatric Trauma Program, Hershey; and Community Health and Wellness (S.L.), Lancaster General Health/Penn Medicine, Safe Kids Lancaster County, Lancaster, Pennsylvania.

Address for reprints: Frederick B. Rogers, MD, 555N, Duke St., Lancaster, PA 17602; email: frogers2@lghealth.org.

This study was awarded the Cox-Templeton Injury Prevention Paper Award at the 30th Annual Scientific Assembly of the Eastern Association for the Surgery of Trauma on January 12, 2017 in Hollywood, Florida.

DOI: 10.1097/TA.0000000000001754

J Trauma Acute Care Surg
Volume 84, Number 2

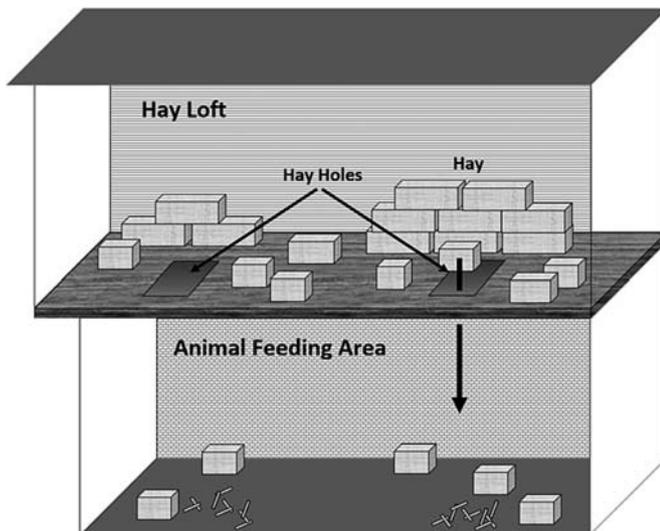


Figure 1. Diagram of Pennsylvania two-story forebay bank barn with hay-holes.

below to the animal feeding area, hay holes are often unprotected, rectangular openings in the second-story barn floor (Fig. 1). While not specific to Anabaptist communities, a recent report by Engbrecht et al.⁸ analyzing the incidence of these injuries in Central Pennsylvania found that 83% of hay-hole falls presenting to their Level I pediatric trauma center afflicted Anabaptists. As such, the authors proposed future research efforts should attempt to delineate the epidemiology of these injuries in the Anabaptist population, while developing interventions to prevent their occurrence.

Although the solution may seem simple—cover the hay-hole—the problem of hay-hole falls is much more complex. Because of poor ventilation in hay lofts, covering hay-holes is objectionable by farmers due to the restriction of air flow this would cause during the hot summer months. As a result, many barn owners leave their hay-holes uncovered as a fire prevention measure. To combat this issue, we sought to develop a hay-hole cover prototype which would be breathable to allow for air circulation, yet strong enough to prevent hay-hole falls. The purpose of this investigation is to detail the design, development, and distribution of these covers, while reporting preliminary feedback on the success of these prototypes in reducing hay-hole falls. We hypothesized that a hay-hole cover meeting the above specifications would be well received by the Anabaptist community, and the installment of such covers would reduce hay-hole falls.

METHODS

After receiving grant funding through the American Trauma Society, Pennsylvania Division, the National Children's Center for Rural & Agricultural Health & Safety, and the Agricultural Safety & Health Council of America, a trauma prevention taskforce was established to address the issue of hay-hole falls in the Anabaptist population in South Central Pennsylvania. Composed of family and emergency medicine physicians, nurses, educators, trauma leaders, and representatives from the Pennsylvania Amish Safety Committee (PASC), the taskforce

was labeled the Anabaptist Youth Trauma Prevention Consortium (AYTPC).

Following the development of two potential hay-hole cover prototypes, the AYTPC brought both models before the Anabaptist community for feedback at a countywide Farm & Family Safety Day initiative. While both covers were well-received by the farming community, one design was selected as the overwhelming favorite due to its durability and ability to effectively ventilate a hay loft. Composed of a 1 ¼ inch diameter thick-walled steel conduit pipe frame with a meshed, nylon netting interior with a breaking point of 719 ft/lb, the cover was designed to be hinged on one side of the hay hole and opened and closed as needed. In addition, the cover also came equipped with a removable lining which could be attached during the winter months, allowing for yearlong use (Figs. 2–4). Preliminary structural testing found the hay-hole cover was able to support at least 620 lbs during net static loading, and could withstand a 150-lb load net drop test from a height of 4 feet.

To beta-test the selected prototype, an initial sample of 25 covers was distributed to barn owners throughout Lancaster County. Following a 3-month trial period, recipients were asked to complete a follow-up survey detailing any difficulties with installation, the frequency/ease of use of the cover, and whether any injuries/hay-hole falls occurred following cover installation.

After this initial testing period, 206 more hay-hole covers were produced and distributed throughout an eight-county area in South Central Pennsylvania. Identification of trauma-prone counties in the area was determined through the use of trauma registry data as well as the guidance of the PASC. As with the initial beta-test, presurveys and postsurveys were distributed to recipients to gain insight into the acceptance, use, and preventive impact of the covers in reducing hay-hole falls. Recipients were asked to return final surveys 3 months following hay-hole cover installation.

To gain an understanding of the epidemiology of hay-hole falls, and insight into the impact of our initiative, all fall-related injuries were queried from our Level II community trauma center from January 2000 to September 2016. Hay-hole fall injuries were identified through review of injury cause text, as a specific International Classification of Diseases, 9th Revision, Clinical Modification External Cause of Injury Code (E-Code) is not presently available for this injury mechanism. Collected variables included age, gender, Glasgow Coma Scale (GCS) score, Injury Severity Score (ISS), length of stay, head bleed, documented concussion, loss of consciousness, facial/skull fracture, lower extremity fracture, upper extremity fracture, spinal fracture, transfer status, insurance type, and mortality.

RESULTS

Of the 25 recipients who beta-tested the initial sample of hay-hole covers in Lancaster, Pennsylvania, 23 (92%) submitted completed presurveys and 19 (76%) completed postsurveys detailing their experience. Results from presurvey feedback found that 61% (n = 14) of recipients reported at least one hay-hole fall on their property, although only 29% (n = 4) of these incidents resulted in serious injury. The median number of hay-hole falls per property was 1.00 (1.00–2.00). The median number of hay-holes reported per property was 3.00 (2.00–4.00), with a

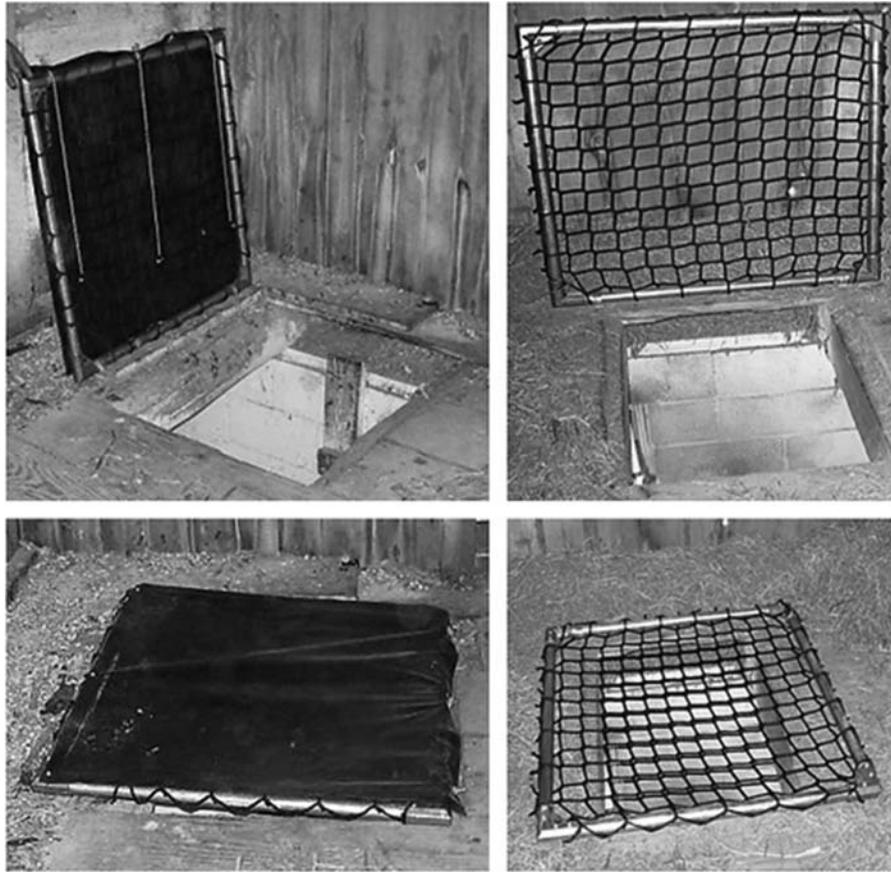


Figure 2. Hay-hole cover installed with and without winter lining.

median self-reported distance from hay-hole to barn floor of 10.0 (8.00–12.0) feet. Postsurvey feedback found a 100% compliance rate with hay-hole cover installation of those who submitted postsurveys ($n = 19$). The majority of recipients ($n = 15$; 79%) reported installing the cover with the winter lining. No respondents reported any problems with cover installation or detailed any injuries associated with cover use. All postsurvey respondents ($n = 19$; 100%) reported using the

hay-hole cover on a regular basis. No hay-hole falls were reported postinstallation.

Following the initial beta-test, 206 more hay-hole covers were distributed throughout a broadened, eight-county area in South Central Pennsylvania. Counties receiving covers included Lancaster, Lebanon, Cumberland, Chester, York, Berks, Dauphin, and Adams. Analyzing the presurvey and postsurvey results of this secondary distribution in composite



Figure 3. View of hay-hole cover from ground floor feeding area up to second floor hay loft.



Figure 4. Aerial view of Anabaptist children dropping hay through hay-hole equipped with hay-hole cover.

with the initial beta-test group (n = 231), 52% of cover recipient respondents reported at least one hay-hole fall on their property (28 of 54 recipients submitting completed presurvey data), with 46% reporting multiple falls (median fall rate: 1.00 [1.00–2.00] hay-hole falls per respondent). The median self-reported distance from hay-hole to ground floor was 10.0 (8.00–12.0) feet, and the median number of hay holes present on-property was 3.00 (2.00–4.00) per respondent. Postintervention survey data found 97% compliance with hay-hole cover installation (36 of 37 submitting completed postsurvey data). Two respondents reported difficulty with installation; however, the majority of recipients reported no issues. No injuries were associated with the hay-hole cover, and all recipients submitting postsurveys reported using the cover on a regular basis. No subsequent hay-hole falls were documented.

From January 2000 to September 2016, 93 hay-hole fall victims presented to our level II community trauma center, comprising 0.74% of the total fall population (n = 93/12,662). Hay-hole falls were most prevalent during the summer months with 49.5% of injuries occurring from May to August (n = 46/93; Fig. 5). Compared with the total fall population, patients with hay-hole fall injuries were substantially younger (hay-hole fall median age: 6.0 [3.0–11.0]; other fall median age, 67.0 [44.0–82.0]). The GCS scores [hay-hole median GCS score, 15.0 (13.0–15.0); other fall median GCS score, 15.0 [15.0–15.0]) and ISS (hay-hole median ISS, 9.0 [5.00–14.0]; other fall median ISS, 9.0 [4.0–13.0]) were not different between the two populations.

Within the hay-hole fall population, 34.4% of patients experienced a loss of consciousness (n = 32/93), 26.9% of patients developed a brain bleed (n = 25/93), and 16.1% were specifically classified as having a concussion (n = 15/93). In terms of fractures, 44.1% of hay-hole fall victims presented with either a skull or facial fracture (n = 41/93), 7.53% presented with lower extremity fractures (n = 7/93), and 5.38% with upper extremity fractures (n = 5/93). In addition, a total of six (6.45%) hay hole fall patients presented with spinal fractures and three (3.23%) with rib fractures. Within the total hay-hole fall injured population, only three patients had formalized insurance plans. The

TABLE 1. Hay-Hole Fall Study Population Demographics

Variables	Hay-Hole Fall Population (N = 93)
Age: median (IQR), y	6.0 (3.0–11.0)
0–5, n (%)	41 (44.09)
6–11, n (%)	31 (33.33)
12–17, n (%)	9 (9.68)
≥18, n (%)	12 (12.9)
Sex, male, n (%)	76 (81.7)
ISS, median (IQR)	9.0 (5.0–14.0)
GCS score, median (IQR)	15.0 (13.0–15.0)
Associated injuries	
Head bleed, n (%)	25 (26.9)
Concussion, n (%)	15 (16.1)
Loss of consciousness, n (%)	32 (26.9)
Facial/skull fracture, n (%)	41 (44.1)
Lower extremity fracture, n (%)	7 (7.53)
Upper extremity fracture, n (%)	5 (5.38)
Rib fracture, n (%)	3 (3.23)
Insurance, n (%)	
Formalized plan	3 (3.23)
Old Order group	32 (34.4)
Uninsured	58 (62.4)
Post-Emergency department destination	
Home, n (%)	12 (12.9)
Intensive care unit/critical care unit, n (%)	13 (14.0)
Medical/surgical unit, n (%)	21 (22.6)
Operating room, n (%)	6 (6.45)
Transfer, n (%)	41 (44.1)
Dead, n (%)	1 (1.08)

ED, emergency department; ICU, intensive care unit; IQR, interquartile range.

majority of injured patients were either uninsured (n = 58/93; 62.4%), or participated in the Old Order Group community coverage plan (n = 32/93; 34.4%). A complete breakdown of hay-hole fall population demographics and injury severity statistics is presented in Table 1.

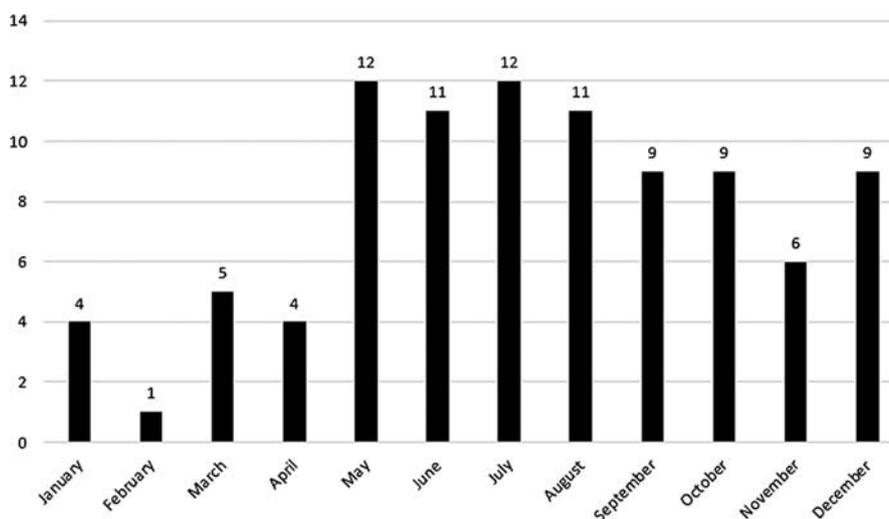


Figure 5. Hay-hole falls by month: January, 2000–September, 2016.

DISCUSSION

As a prevalent source of mortality and morbidity among children and adolescents,^{9–14} characterizing the epidemiology of pediatric fall trauma is essential to develop effective preventive interventions to combat these injuries. While extensive research has investigated pediatric falls in urban environments,^{9,11} rural fall injuries, specifically pertaining to hay-hole falls,^{7,8} remain vastly understudied. As a result, outreach efforts to address these injuries within the trauma-prone rural population are scarce. This study sought to use previously reported data detailing the issue of hay-hole falls in rural Anabaptists as a guide to develop an effective hay-hole cover intervention program to prevent future injuries within this at-risk population. Through the establishment of the AYTPC and the development a collaborative relationship between the PASC and medical community leaders, we feel we have produced a well-received hay-hole cover prototype and distribution model that could be adapted and expanded to prevent hay-hole falls in other rural regions across the United States.

Viewing the results of this intervention initiative in composite, it is apparent that hay-hole falls are a prominent issue within the Anabaptist community. With 52% of survey respondents reporting at least one fall, and 47% multiple falls on their property, it is likely the incidence of hay-hole falls is far greater than any emergency department or trauma registry data would suggest. By examining only formalized hospitalization records, we are undoubtedly missing a large percentage of individuals who are suffering minor hay-hole fall injuries and not seeking medical attention. Therefore, having the opportunity to directly connect with Anabaptist community members and query these individuals regarding the incidence of hay-hole falls on their property, we are able to further our epidemiological understanding of these injuries.

Although the incidence of hay-hole falls is relatively low, the fact that these occurrences often result in serious injury among a predominantly uninsured, underserved population beckons to the necessity of targeting this trauma mechanism within the Anabaptist community. Similar to the work of Engbrecht et al., our institutional analysis revealed disproportionate levels of craniofacial injuries among our hay-hole fall victims. Although the mean age of hay-hole fall-injured patients presenting to our Level II adult community trauma center skewed older than that of Engbrecht et al.'s pediatric center, craniofacial injuries were still found to be the dominate injury pattern in these individuals. Considering barn owners typically bend over to place hay down the hay-hole, it is understandable how a slip or misstep, combined with forward momentum, could result in a fall with forward rotation, causing these individuals to land on their head or face on the concrete floor below.

As the incidence of hay-hole falls is relatively low, and the majority of barn owners have multiple hay-holes on their property, no formalized statistical measures were used to assess the efficacy of the hay-hole cover in reducing falls. For the preliminary phase of this initiative, participants were only allotted one hay-hole cover per household to raise awareness and increase distribution efforts throughout a wider region in South Central Pennsylvania. It is unlikely any statistically significant decrease in hay hole falls would be observed during this preliminary phase. Moving forward, efforts will focus on covering

all hay-holes throughout the region, particularly individuals with multiple hay-holes on their property.

This study is not without its limitations. As the nature of this investigation was survey-based, our understanding of the efficacy of our hay-hole cover prototype and the incidence of hay-hole falls within the Anabaptist community is limited to the information we received from those who completed presurveys and postsurveys. As a poor overall response rate was expected from the Anabaptist community, future distributive efforts will seek to combat this issue by following-up with hay-hole cover recipients—despite this population being difficult to reach. In addition to the poor response rate, as participation in this investigation was voluntary, and barn owners with hay-holes in South Central Pennsylvania were not randomly selected to test our developed hay-hole cover, our results are likely influenced by response bias. Individuals who previously had issues with hay-hole falls were undoubtedly more likely to seek out a hay-hole cover prototype to test. In an attempt to combat this limitation, however, our distribution efforts covered a wide geographic area as a means to achieve a broader sampling.

CONCLUSION

Often associated with severe injuries, hay-hole falls pose significant physical, emotional, and financial burden for those both directly and indirectly affected. Although prevalent in Anabaptist communities, particularly among children and adolescents, hay-hole falls are an issue for many rural populations relying on farming to sustain their way of life. With the support of the AYTPC, we developed an aerated hay-hole cover which could effectively reduce hay-hole fall trauma across other rural communities in the United States.

AUTHORSHIP

E.B. participated in the study design, data collection, data analysis, data interpretation, article preparation, critical revision. B.G. participated in the study design, data collection, data analysis, data interpretation, article preparation, and critical revision. S.J. participated in the data analysis, article preparation, and critical revision. E.B. participated in the data collection, data analysis, data interpretation, article preparation, and critical revision. R.B. participated in the study design, data collection, data interpretation, article preparation, and critical revision. M.R. participated in the study design, data collection, data interpretation, and critical revision. D.M. participated in the study design, data collection, data analysis, data interpretation, article preparation, and critical revision. K.M. participated in the study design, data collection, data interpretation, and article preparation. J.H. participated in the study design, data interpretation, and article preparation. S.L. participated in the study design, data collection, data interpretation, manuscript preparation, and critical revision. J.A.M. participated in the study design, data collection, data interpretation, article preparation, and critical revision. F.R. participated in the study design, data collection, data analysis, data interpretation, article preparation, and critical revision.

ACKNOWLEDGMENTS

We acknowledge the contributions of Paul Stoltzfus, Samuel Blank, and Henry Zook of the PASC for their assistance with the design and distribution of the hay hole covers, and for their commitment to the prevention of rural trauma among the Anabaptist population.

DISCLOSURE

Disclosure Statement: The above authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

Funding: The following entities provided grant funding for hay hole cover development and distribution.

1. American Trauma Society, Pennsylvania Division.
2. National Children's Center for Rural & Agricultural Health & Safety.
3. Agricultural Safety & Health Council of America.
4. Penn State Hershey Children's Miracle Network.

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