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Farm Injury and Safety Practices Among Rural Adolescents: A Qualitative Analysis to Support the Development of a Gamified Educational Resource

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ABSTRACT

Objectives: Little is known about adolescent experiences of injury and adoption of safe or unsafe practices on farms, despite adolescents being at-risk of fatal and non-fatal injuries in the farm setting. To enhance understanding and inform the co-design of farm safety educational materials for teens, we aimed to explore farm injury experiences, safety practices, and educational preferences for secondary school students and their teachers.

Methods: Nine focus groups of mixed gender students (year 7 and 8) and five one-on-one teacher interviews were conducted at three high schools teaching agriculture in rural Australia, across the states of New South Wales and Tasmania. Inductive thematic analysis of session transcripts was undertaken.

Results: Five overarching themes emerged: "safety is not always front of mind"; "farm injuries are commonplace and downplayed"; "learning opportunities"; "school has a role"; and "teach me, but make it realistic and fun". Students indicated injuries were inevitable, and widespread unsafe practices occurred. Farm safety information was received from parents or while on the job, although in some cases parents encouraged unsafe behaviors. Curriculum linked materials are important, yet teachers also saw the value in covering additional material outside of mandated content, as it is often relevant to students' real-life experiences on farms. Students expressed interest in game-based learning on this topic but were adamant it needed to be fun and realistic.

Conclusion: Farm injury is preventable, and opportunities exist to educate adolescents about farm injury prevention via fun and engaging materials delivered at school. Insights from students and teachers around preferred educational design and content have informed the development of the "Calm Your Farm" (www.calmfarm.education) online gamified educational resource and may also be helpful to others working to influence farm safety practices among a typically difficult to engage age group.

KEYWORDS
Adolescent; agriculture; education; participatory research; rural; safety

Introduction

Injury among adolescents (ages 10–24 years)[1] is an important yet neglected public health domain. Despite being a significant cause of preventable mortality and morbidity,[2] there remains limited evidence globally regarding effective interventions for adolescent injury prevention.[3] The limited evidence base impacts investment in adolescent injury, and broader health and well-being, which lags behind that of younger children.[4]

In Australia, several injury mechanisms appear in the top five causes of death for adolescents, including land transport incidents, suicide, unintentional poisoning, and assault.[5] Injury risk is greater for those residing in regional and remote Australia, due to a range of factors including distance to medical assistance, higher speeds, and riskier occupations.[6]

The farm, as a home, a workplace, and a place for recreation, represents a unique environment with its own injury risks.[7] Various hazards are present that can cause injury, including electricity, unfenced water bodies, vehicles (e.g., quad bikes), agricultural machinery, and livestock, including large farm animals.[8] Sensation seeking and risk taking, which can peak in adolescence,[9] also contribute to injury risk during this life stage. Determining farm injury risk for adolescents is challenging due to a lack of data disaggregation by age group.[10,11] Of concern, fatal farm incidents among children under 15 years-

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of-age in Australia have remained unchanged since the early 2000s.[12]

Despite these challenges, the adolescent years also represent an opportune time to provide farm safety education.[10] Adolescence is one of the last opportunities to intervene before adulthood, where influencing behavior becomes more difficult,[13] ensuring safe occupational practices are embedded before entering the workforce. A systems-level approach to the provision of this education, such as via schools,[14] has the benefit of reaching a broader cohort, including visitors to the farm who are at increased injury risk.[12] Research shows co-designed materials are effective for adolescents[15,16]; however, to ensure uptake of created materials in the school setting, it is vital teachers are included in any resource design.[17]

To inform the development of the Calm Your Farm online educational resource (www.calmfarm.education.),[18] this study aimed to understand experiences of farm injury and safety practices among rural dwelling secondary school students and their teachers. We also examined current farm safety education received and how any future educational resource on farm injury prevention could be better optimized for adolescents.

Methods

This was a descriptive qualitative study using semi-structured focus groups with students and one-on-one teacher interviews. The published protocol details the study methodology,[19] but methods are described briefly below. This study describes the qualitative component that took place ahead of game development and prior to pilot evaluation.[18]

Study participants and recruitment

Using author networks and snowballing techniques, agricultural high schools or schools teaching agriculture were approached for potential participation. An email was sent to a contact point (generally the agriculture teacher) describing the study and requesting a follow-up phone or Microsoft Teams call to provide further information. Following the call, further information was provided via email to facilitate Principal approval. For eligibility, schools needed to be in a regional or rural location, teach agriculture to students in years 7 and 8 (ages 12–14 years), available within the project timeframes, and ideally represent diversity in geographical area, primary industries, and types of agriculture. Final schools selected were a public secondary school in rural Tasmania and two independent schools teaching both primary and secondary students in rural and regional New South Wales.

Author AEP worked with the contact point of the schools (either class teacher or office staff) to circulate the participant information and consent form (PISCF) to students and their parents. Signed PISCFs (by both parents and students) were collected by author AEP during data collection and those students for whom parents did not consent (<5) were provided with other tasks during the sessions. A signed PISCF was received from the teachers prior to their interview.

Discussion guides

Separate semi-structured discussion guides were developed for students and teachers, found in Supplementary File 1 and 2, respectively. The student discussion guide included questions about farm safety and injury prevention, school-based farm safety education, and gamified farm injury prevention. The teacher discussion guide included similar questions with a focus on what farm safety information was provided at school and how the proposed gamified resource could be best utilized in-classroom. Extensive field notes were maintained by author AEP and consulted after each session. No refinement to the discussion guide was deemed necessary after reviewing field notes.

Data collection

A convenience sample of focus groups and one-on-one interviews were held at the participating schools in March and April, 2023, and amounted to all students and teachers who met the inclusion criteria (year group) and for whom informed consent to participate was received. Sessions were audio-recorded and transcribed for analysis. No reimbursement was given to participants. While conducting data collection, author AEP kept

a reflexive journal comprising field notes and personal reflections during and after each focus group or interview. These were reflected on during analysis to make sense of the data and acknowledge any pre-conceived ideas or biases.

Analysis

Transcripts were analyzed by author AEP. Descriptive procedures were used to analyze the data for emerging themes and sub-themes. An inductive approach as outlined by Braun and Clarke[20] was used. Five phases were followed: first, author AEP familiarized the data by rereading the transcripts and field notes and noting down initial themes (phase 1). Initial themes were generated by systematically coding interesting features of the entire data set (phase 2). Author AEP then reviewed the themes generated, solidified, and developed a thematic map for coding (phase 3). The data were then analyzed into themes by author AEP (phase 4). Author RF performed an independent coding of a 20% subset of transcripts ($n = 3$). Authors AEP and RF then met to compare the contents of each theme and identify any missing or conflicting themes (phase 5). Themes that emerged across both student focus groups and teacher interviews were explored together.

Themes are depicted with select respondent verbatim quotes, with edits for grammatical purposes depicted in square brackets. Quotes are attributed to the participant group in which they were said (i.e., student group [SG] 1 or teacher interview [TI] 3), rather than to the individual participant.

Ethics and informed consent

Ethics approval was granted by the University of New South Wales Human Research Ethics Committee (approval number: HC220791).

Results

Nine mixed-gender focus groups with students ($N = 86$; groups ranging in size from 6 to 12 participants; age range 12–14 years) and 5 one-on-one teacher interviews ($N = 5$; age not recorded) were held. Five overarching themes emerged from the analysis: Safety

Table 1. Key themes, explanations, and sample quotation.

Theme number	Theme name	Explanation	Sample quotation [group]
1	Safety is not always front of mind	Farms are risky environments, and students often took calculated risks, sometimes using safety practices, and other times deliberately choosing not to	*"Well, if it's for work, though, it's a different story. If you're working on your motorbike, you're going a lot slower. If you're mustering stock or something, you're obviously not going to be flying around. You're taking more precautions pretty much. But if you're just having fun … "* [SG5]
2	Farm injuries are commonplace and downplayed	Many students themselves had been injured or knew of others that had, some seriously. There was a sense of inevitability about injury and it was often brushed off as not a big deal or just part of life on the farm.	*"My dad's only got seven fingers. He lost two when he was trying to take off a PTO [power take-off] and lost one in the auger"* [SG3]
3	Learning opportunities	Learning occurs from families (both safe, and unsafe practices) and also learning while doing (i.e., on the job)	*"My dad just tells me. When I'm filling out the spray and you get taught safety and that. But most of it just common sense because it's not like just put your hand in the chemical. When you're filling up, you don't touch the chemical"* [SG3]
4	School has a role	Although learning was occurring via family and on the job, students recognized school was also an opportunity for learning about farm safety	*"All the precautions on tractors and stuff. Lots of things that you wouldn't think of at home, if you're on them all the time, where they're just every little detail. They try and get you to learn it"* [SG5]
5	Teach me but make it realistic and fun	Students were interested in learning but wanted learning materials to be fun and engaging, in direct comparison to the less engaging materials they currently received farm safety education through	*"But honestly, you want a farm that's honestly, I won't swear, but the shit going wrong because that just makes it more alive. You don't want some crazy little hobby thing that's everything's fine because then it just gets boring"* [SG4]

is not always front of mind (Theme 1); Farm injuries are commonplace and downplayed (Theme 2); Learning opportunities (Theme 3); School has a role (Theme 4); and Teach me but make it realistic and fun (Theme 5). These themes are summarized in Table 1 and then further discussed.

Theme 1: safety is not always front of mind

Students perceived farms can be risky places. When asked about hazards on the farm that can hurt you, one student replied *"Pretty much everything. If you're an idiot, if you're not careful."* [SG5]. Students described numerous practices on the farm that could lead to injury. These included sticking fingers in augers: "*Well, if the seeds get blocked up and you've got to flush it through*" [SG3] and going out alone shooting on the farm: "*No, just on my own. It's just not far, though. It's just shooting*" [SG2].

There was a tension between safety and completing what needs to be done on the farm. Students indicated safety precautions, such as helmets and seatbelts, were perceived as getting in the way of performing a task or made performing that task harder or slower. Seat belts were described as being " *... too much of a hassle getting in and out of vehicles and stuff all the time. Lots of farmers don't wear seatbelts*" [SG5]. If not wearing seatbelts, students indicated safety measures comprised "*closing the door so you don't fall out*" [SG5] and being "*a bit more careful I suppose*" [SG5]. There was also a clear delineation between safety practices off the farm as opposed to on private property (the farm): "*You do all the time on the road. You wear your seatbelt there because you have to legally, but when you're on your property, you don't. That's kind of your decision*" [SG6].

While some students described safety as not being considered ahead of time: "*lots of people don't think about what they do before they do it*" [SG5], others described a risk assessment process of sorts, whereby a conscious decision was being made on when to use safety equipment and make safer choices and when it was deemed unnecessary, depending on the task. Many students performed this assessment when riding a motorbike and choosing whether to wear a helmet or not:

> I'd probably [wear a helmet] when you're doing jumps and stuff. But not if you're just having a cruise around the farm and stuff [SG1]

> It depends where I'm riding. If I'm just going down to the workshop, then I'm not. But if you're going on a proper ride, then yeah, sure [SG4]

> Well, if it's for work, though, it's a different story. If you're working on your motorbike, you're going a lot slower. If you're mustering stock or something, you're obviously not going to be flying around. You're taking more precautions pretty much. But if you're just having fun ... [SG5]

The same example spanned safety gear beyond helmets:

> Well, at home I'm just mucking about. I'm just jumping through gullies and all that. But at a mate's place, I'm proper jumping and riding a track. [it's] high, faster, 100-foot jumps and all that. I'm not going to hit that in jeans [SG5].

Similarly, decisions on whether to wear a seat belt or not were based on farm terrain

> Depends on the terrain of our paddocks. Because we've got some that are really flat and some that are really steep. So it just depends, more fun leaving your seatbelt off. [SG8]

Another student indicated that helmet wear was based on both the intended task and comfort:

> It's just like you sit and go slow because you're just moving sheep around or something. You don't have to, you can just sit there instead of sitting in a helmet, sweating, and stuff like that. [SG3]

However, adopting safer practices could conversely lead to unsafe practices as one student described:

> It all depends. If we're moving animals or something, I'm not wearing a helmet. But if we're going out of our property or something, and I wear my helmet, I find that you have that helmet on you feel like you're a lot safer so you just don't want to go slow. You just want to go faster [SG4]

Decisions on speed when operating farm machinery were also task-dependent:

> I go appropriate speeds when you're planting, but if you're not planting or doing anything like that, you can just go as fast as you want. [SG2]

This risk assessment was also context specific:

> We have the river running through our property, so we go for a swim down at the river. There's sort of a rise spot. On the bank, it goes down to where the causeway is. And our parents usually stand there and there's a turn. It's really deep there, so we're not allowed to go past there. And there's also a part that's shaded by pine trees, and we can go a little bit down there, but not too far. [SG2]

Many students reported they were experienced, having been performing a certain action or activity for many years, despite their young age, and appeared to suggest their experience negated the need for protective equipment or safety precautions. When it comes to motorbike or quad bike riding, several students expressed that they do not wear a helmet because

> I've been riding motorbikes since I was seven" [SG1] and "I've been riding since I was four [SG1]

Unsafe practices also arise out of exposure and opportunity

> we're living on a farm [we drive] everything on the farm, not legally but," [SG3] while for others, safety is seen as boring or getting in the way of having fun: "I'm really careful. I don't have any fun" [SG4], "Good memories come from it [getting hurt] [SG4]

Theme 2: farm injuries are commonplace and downplayed

When asked, almost all students could recount times when they themselves had been injured. Many of these involved vehicles, such as motorbikes and buggies:

> Last term, I had an accident on my motorbike. I fell off my motorbike from going too fast and getting the death wobbles and hit the front brake and went over [SG 3]

> One of my friends, they were driving near a creek in a buggy, and the buggy flipped over, and they're trapped in the water with the buggy upside down [SG5]

Injuries were also described as occurring due to livestock

> We have been kicked by lots of animals" [SG4], horses "I was washing the horses and it stepped on my foot and my foot broke and it hurt so much" [SG2] and farm tools "I was cutting hay bales and I slipped with the box cutter and cut my leg [SG4]

Many recounted quite serious incidents they had experienced but, when described during the focus groups, were downplayed. These included incidents causing cuts

> Well, I tried to jump a barbed wire fence, and I caught my arm on the barbed wire and ripped my whole arm." [SG1], motorbike incidents "This was pretty dumb. I made a little jump and tried to go over a rock. I completely missed the jump and hit the rock and my motorbike … I flew over the handlebars and the motorbike ran over me" [SG1], and quad bikes "I used to go and take my friend out for a shoot. We were on the quad bike together, and she hit a fence, and we went over the fence, and I landed in a tree [SG5]

Students also recounted serious injuries occurring to others, either family

> My dad's only got seven fingers. He lost two when he was trying to take off a PTO [power take-off] and lost one in the auger" [SG3], or people in their community "A mate's dad, on a Bobcat, the bucket fell off and squashed him. Instead of crushing him, he was all just dislocated and everything, like knees, hips, elbows, shoulders [SG5]

When discussing previous injuries that had occurred, there was a sense of inevitability, as one student said "*injuries can happen anyway*" [SG4]. When discussion turned to whether injuries could be prevented views were split but apathetic, with one student suggesting "*Well, you can't really. Kids got to be kids sometimes*" [SG5], while another student suggested

> Well, they can. But sometimes it's not worth it. That's too much of a hassle [SG6]

Teachers also mentioned that farm injury is commonplace among students:

> "I don't have any kind of individual knowledge for staff. I know that a lot of students work on farms, and I know that there have been some, I have had instances where I've had a student say, oh, I had a minor injury because of XYZ with the cows or with something like that, with their livestock. They were being stupid with this or that generally is the case. [TI1]

> We actually talk quite a bit about people getting hurt and we formulate the farm rules as a workshop each year rather than me simply giving it to them. We guide them, but people don't think about the dangers on farm. The kids are aware of the dangers with motorbikes and

> tractors, but I think there's a bit of a 'won't happen to me' attitude. [TI2]

Injuries were described as occurring due to many years of experience, even at a young age, leading to complacency:

> Just getting casual with it, getting used with it, and not trying – being silly sometimes [SG3],

and comfort

> You get too comfortable with it, so you might do it right. And you're like, 'Oh, yeah, I know how to do this,' so you go do it again, and you get too confident. Then you think you know, and then something goes wrong [SG3]

Theme 3: learning opportunities

Family was an important source of farm safety information with many students indicating that they learned from their parents:

> Like at my grandpa's and grandma's and that because they would get a bit worried about me. Sometimes they're like, don't go as fast as you do when you're at home. Since it's a different bike that you're riding, get used to it before you actually start to speed up. And this is what's changed, so be careful with it. [SG2]

This safety information from parents was often communicated while performing the task:

> We have a rule about our slasher. If you're going out in the paddock, and I see dad slashing, never get too close, stay as far away as possible. So dad used to take me in the tractor when I was about three, and he would always tell me, If you're going down a hill, always make sure you're at a slow pace so it doesn't roll because on slashed grass, it can be slippery sometimes. And if you're raked facing down a hill, always be careful because it might start rolling. [SG2]

> My dad just tells me. When I'm filling out the spray and you get taught safety and that. But most of it just common sense because it's not like just put your hand in the chemical. When you're filling up, you don't touch the chemical [SG3]

Many students suggested exposure to work on the farm taught them what to do as they are

> Brought up on a farm. You figure out what goes and what doesn't" [SG5], particularly by the time they reached adolescence "I reckon if you've been brought up around it, by about now, you're starting to figure it all out" [SG5]. But observing what their parents did was also a core component of their farm safety knowledge. As one student said "To be honest, you can learn a lot from your parents. Because if you're with them all the time, you get to watch what they do" [SG5], "Follow them pretty much on what they do. Don't do anything else [SG5]

Though more in the minority, some students indicated that they learned about safety information by not following in their parents' footsteps:

> Well, just about quads. Don't go too fast because once my dad did donuts, and it flipped" [SG2], or that their parents did not put such a focus on farm safety: "I just say because we've got a bunch of a lot of rabbits on the hill nearby. So we just say, Dad, I'm going to shoot him. He says, okay. Because he's like, I don't legally own it, but he gave me a 22 for my birthday. And it's just a 22. So, I just go out and shoot rabbits" [SG2], and "It's just what I do. And they just see me going full on speed and they just laugh [SG2]

Some students indicated they received very little safety information, with a focus on learning how to "do" rather than to be safe "*Doing that [driving tractors]? Not much. We just learn how to drive it*" [SG2], or that they had to teach themselves about farm safety "*we had to teach ourselves how to be aware. We just have to do it ourselves a lot*" [SG3].

Family circumstances and farm work also caused a tension whereby children were exposed to farm injury risk due to pressure to help out on the family farm:

> My parents, my mum's always at work or looking after the kids. She's got jobs in town. Then dad, he's on the farm, or he's out contracting, or whatever. But he needs help, so me and my younger brother, we are going to drive tractors. Take the auger here, take pigs from this block [SG3].

However, students were also mindful of how disruptive getting injured could be for the running of the family farm:

> Yeah, I have to, because my dad, like, so if I fall off and hurt myself, I have to go to hospital and he has to take time off work, so he makes me and he says, if you don't wear stuff and you hurt yourself, I'll sell your motorbike [SG6]

Theme 4: school has a role

Beyond farm safety education received (or not) on the farm and from family, students also received information from the school, although some indicated it was minimal:

> Yeah. To prevent it [farm injuries]. But we didn't do a heap on it. It was like 10 minutes of it" [SG 1], and "Not really. Well, our first few lessons, we wrote down rules, like farm rules in our books and safety things before we got into any of the actual prac [SG2]

Others felt like they received a lot of information given their schools were agriculturally focused:

> You get a lot of it here at school, in an Ag school" [SG5], "Look it around here. It's everywhere. Signs everywhere saying what to do and what not to do. Everything that our teacher tells us to be safe and all that [SG5]

Students acknowledged that school has an important role to play in providing farm safety education, as it's different from what is provided at home

> All the precautions on tractors and stuff. Lots of things that you wouldn't think of at home, if you're on them all the time, where they're just every little detail. They try and get you to learn it" [SG5], or to address the absence of farm safety information at home "We don't do much outside of school on farms [SG1]

Several teachers mentioned that farm safety was absolutely an important topic to be taught, even if they were providing students with information not directly related to the practical agriculture-related tasks they got to participate in during their studies:

> Absolutely, because as teachers, we educate on lots of things that mightn't be done at school. For example drugs, alcohol, this is something else that students are engaging in. For farm safety, often the only source of information could be an older cousin who they've gone out to the farm with, who mightn't be very safe. We hear all the time that kids don't have PTOs [power take off] covers or ROPS [roll over protective structures] fitted to equipment and so it's really important that they often act as a bit of a conduit of information home as to what is safe. So even though we are only teaching machinery use from year ten and upwards for the certificates one and two in agricultural rural operations, we're still teaching about that farm safety and risk assessment because they could be using equipment at home that they're watching me demonstrate. [TI2]

> Yeah. They're getting safety information which is specific to whatever it is that they're doing. But as you mentioned, chemicals, they won't have much to do with chemicals in that. No, they don't cover it at all. So having touched on that like initiative, the chemicals and compressed air, like those little things that the curriculum doesn't provide. Our kids are exposed to at home but just not in the curriculum. [TI3]

Educational content about farm injury should also evolve as students grow to reflect the tasks they will increasingly be likely to take on as they grow older:

> I think that's really relevant because as the kids get older, things such as chemical safety need to be taken into account. And these kids are then often doing a lot of work to harvest themselves. It's not uncommon for these kids to be doing that and often visitors are sat in the tractor. And it's all fun until something goes terribly wrong. [TI2]

School can also provide farm injury prevention information to students who do not live and work on farms, but who, by virtue of living in rural areas, may visit their friends or families on farms. They can be at even greater risk of injury due to the unfamiliar surroundings as one teacher described:

> It's really important because it's actually the kids on farms will actually pull up when unsafe behavior is occurring on the school farm because they've probably been scared enough, hopefully by their parents of what the consequences could be. Whereas it's the kids that are engaging in agriculture for the first time who don't see things. And for an example, today I saw a chipping hoe being swung around the head. They don't see how dangerous that could be. [TI2]

Theme 5: teach me but make it realistic and fun

In terms of preferred farm safety education, particularly in the form of a game, students indicated challenges in making the game appealing and some thing they would play at home. As students said:

> Kids our age, not to be rude, but we're on Fortnite or Call of Duty. I don't know any kids or friends that don't play those sort of games and would go

> and like, 'I'm not going to play this. I'm going to go play farming'. [SG1]

> It depends how the game turns out. If it's fun, yeah. If it's one of those just educational, it's all that it is. It's just really boring, yeah. I would only play at school [SG2]

When asked about design and content, one of the most important themes students raised was that they would prefer the game be realistic:

> Make it realistic. Like you're really driving it" [SG1], "I feel like you should make them look actually real. Not like cartoons" [SG1], particularly compared to other farming games "I've seen people play it. What you do to get a trailer on you have to press a button. It doesn't show you, "Oh, you got to pull it in, put the pin in, put all the safety stuff. It's not realistic. [SG1].

Several students stressed that a realistic game would depict the farm as it really is, a busy place with lots of things happening at the same time:

> But honestly, you want a farm that's honestly, I won't swear, but the shit going wrong because that just makes it more alive. You don't want some crazy little hobby thing that's everything's fine because then it just gets boring" [SG4], "Like have a story to it. Not every day is the same thing. Something different is always happening [SG1]

Linked to realism was ensuring that the game content was age appropriate *"Don't make it a baby's kind of game." [SG2]*, and that students would be able to see the consequences of unsafe actions: "*You have to show them what's going to happen if they do it*." [SG1]

In addition, the content should be educational but also fun and engaging:

> Would it be really boring if you have to answer these questions? Or would it be something that we would actually enjoy? Actually, make it fun. Don't put ads in it. Make it realistic. Don't make it … You have to do a lot of reading and answer a lot of questions [SG4]

This would be in stark contrast to the farm safety education provided currently during school hours:

> On a video. We got shown a video, and it was just animated. It was some tractors and stuff. Then it was just basic common sense, really. And going to some links [SG3]

> Every year for Ag and technology, we have to do "On Guard". It's pretty well with Ag. It's common sense. It's just questions. It's like, "Do you do this?" And it's either yes, no, all these answers are correct. This is a safety hazard. This isn't a safety hazard. It's multiple-choice questions, but some are just true and false. But some of it's just common sense, but they make you read through the stuff. But sometimes you just don't. [SG4]

In short, the students wanted an educational game that was not overtly about learning:

> Don't have it too complicated. Make it a bit, I suppose, easier. Easy but hard. Easy how to play, but hard learning [SG4]

> Yeah. Make it so you're being taught without you actually knowing you're being taught [SG2]

For the game design students suggested to not "*make it too American*" [SG4] and to avoid stereotypes "*Just don't use farm stereotypes. They're wearing checkered shirts and straw hat and stuff like that. That really annoys me*" [SG2].

From the perspective of teachers, for any resource to be usable it needed to clearly link to the curriculum:

> It makes it easier to incorporate into your teaching programme. But if there's a couple of curriculum links or dot points that it covers, then it's an easy go-to. Teachers will actually gravitate to it and use and implement it [TI4]

Teachers believed a farm injury prevention and safety game would be a useful supplement to less engaging, yet mandatory, agricultural safety materials already in use:

> As they start to use more dangerous tools and equipment, then they get more and more of those tests that are quite boring. It's probably a good way to break it up [TI3]

When shown draft designs, teachers thought that the intended approach using principles of gamification would enable learning through repeat play, as long as the emphasis was on fun:

> Actually, now that I've seen it, I think that the kids wouldn't have a problem doing it again. Like if you were to say, give you one chance this lesson, another chance next lesson, to improve your thing. I think that they'd probably jump at it because it looks fun [TI4]

Table 2. Insight derived from qualitative co-design processes and impact on design and content of "Calm Your Farm" educational resource.

Insight	Impact on "Calm Your Farm" educational resource
Emphasis in discussion on risk taking practices and injurious events associated with vehicles, animals, and water	Findings in combination with data on farm-based injury incidents and deaths among adolescents in Australia saw three of the four game's modules focus on vehicle safety, water safety, and safety in the paddock.
Preference for fun and engaging content	In the design, preference was given to interactive tasks with where students learned via doing rather than reading. Time-based challenges, where the students' scores were higher the faster they completed a task, were also utilized across the game.
Limit reading required	Simple to understand text was used and text-to-voice functionality was added to assist students with reading difficulties, English as a second language or visual challenges.
Preference for realistic information on risks and consequences of actions	Risk of injury and death, including use of real injury statistics as pop ups incorporated, though some harms depicted stylistically rather than realistically to ensure suitable for use in schools.
Recognition of family, in particular parental role in on-farm safety education	The role of the family, in particular parents in providing farm safety education, was recognized with the inclusion of safety messages to be used in the home to further support school-based learning via the game.
Insights from teachers regarding relevance to curriculum	To assist teachers in utilizing the resource in the classroom, the game website also features curriculum mapping to link game content to the broader curriculum across school and VET and a range of ages, as well as lessons plans for in-classroom implementation.
Security and IT challenges in the school setting	Teachers shared a preference for quick and easy start up of game, rather than the planned single sign in option and creation of leaderboards with scores and teams which were originally planned.

Discussion

Given the persistent burden of farm injuries for adolescents,[12] farm safety educational resources that are linked to curriculum and consistent with other resources are vitally important. In speaking with secondary school students and their teachers in rural NSW and Tasmania, rich insights were derived on farm injury, safety practices, and how farm safety information is currently received and could be optimized. These insights were incorporated into the content and design of Calm Your Farm as shown in Table 2 and further discussed below.

The study revealed students recognize farms as risky environments but often prioritize task completion over safety precautions. Farm injuries are common, and their seriousness is frequently downplayed. Students primarily learn about farm safety from family and through on-the-job experiences, though this education is sometimes minimal. Schools play a crucial role in enhancing farm safety awareness, especially where family education is lacking. However, students prefer safety education that is realistic and engaging, favoring fun, immersive games over traditional, straightforward educational methods. Teachers also see the value in such gamified approaches, provided they align with the curriculum and maintain student engagement. These findings were incorporated into the design of the Calm Your Farm game first, by utilizing interactive and time-based tasks to encourage repeat game play. Second, to support teachers, the game's curriculum linked content was further highlighted through curriculum maps and lesson plans for teachers which were made freely available on the Calm Your Farm website (Table 2).

However, adolescents represent a challenging age group for injury prevention[21] due in part to sensation seeking and risk taking.[9] Student focus groups, and to a lesser extent teacher interviews, identified widespread unsafe practices leading to injury on the farm, noting that this behavior was also often rationalized (i.e., safety practices make the task slower; these things just happen). Although encouraging safer practices among adolescents can be difficult,[22] our focus groups also highlighted students wanted any resource developed to be realistic and to show the consequences of their decisions. Taking these insights into the development of the game appears to have been positive. Pre/post surveys administered to students after piloting the game identified statistically significant improvements in self-reported knowledge post-play for boys

on water safety and 13-year-olds on vehicle safety.[18] Of the students, 61% also agreed the game taught them more about farm safety and was more fun than other farm safety education previously received.[18] However, further evaluation, perhaps in the form of additional qualitative data collection, is needed to determine if Calm Your Farm has captured what students were seeking with respect to realism, and whether it has had any long-term impact on farm safety behavior. Similarly, although key farm injury mechanisms for adolescents were incorporated into the game, many of which were mentioned by students, consideration needs to be given as to how to capture evolving responsibility and risk as adolescents grow, as well as the evolution of the game to become harder if students replay the game multiple times.

Student focus groups indicated that family, in particular parents, were an important source of farm safety education for adolescents, noting that some parents were also accepting of unsafe behaviors. Other public health research has shown the benefits of family role modelling on child health.[23–25] The Calm Your Farm game website includes a page of information intended for parents and teachers (https://www.calmfarm.education/learning-materials), although additional resources could be developed specifically aimed at parents. These could include materials that convey the importance of modelling safer behaviors for teens and tools to discuss farm safety at home, supporting game content delivered at school. Such an approach has seen improved outcomes for children across other health topics.[26]

This study highlights the benefits of a co-design approach, with insights from students and teachers at the commencement of the project built into the initial game designs and prototypes that were then taken back to the students for pilot evaluation.[18] Co-design has been shown to result in effective interventions for a range of public health issues for adolescents.[16,27,28] Further, taking the time to visit regional and rural areas for a resource aimed largely at adolescents in these communities was vitally important, given the scope of rural–urban differences, including in injury risk.[29,30] It should be noted that co-design takes resources (time and cost) and this needs to be taken into account when developing programs.

Ensuring school involvement in the co-design was vital, both as a conduit to students and teachers. School involvement is necessary for the implementation of any population-level intervention,[31] and developing resources for implementation via schools (such as curriculum maps and lesson plans) necessitates teacher insights to best support in-classroom use. Given increased farm injury risk among adolescent visitors to the farm environment,[12] systems level approaches, such as via schools, are important. Further work is required to encourage the use of Calm Your Farm outside of agricultural schools to ensure those at potential risk of farm injury have the opportunity to benefit from its educational content. Further, given the important engagement opportunity this research presented to discuss farm injury and its prevention with adolescents, it should be considered a potential educational model in itself to improve farm safety practices. We encourage further testing of this approach in future, in order to better understand its effectiveness.

Strengths and limitations

This study is believed to be the first analysis of qualitative data collected with adolescents regarding farm injury and safety practices in Australia and provides valuable insights into the development of farm injury prevention educational materials. However, there are several limitations to note. The use of focus groups can be an advantage, as interactions between participants can provide important insights[32]; however, this could have prevented some participants from speaking up, meaning we may have missed alternative viewpoints. Similarly, the size of the focus groups, and the enthusiasm of the students, at times made the transcripts difficult to analyze due to cross-talk. Information collected only reflects the views of those involved and the context where the focus groups and interviews took place with 86 students and 5 teachers, as such findings may not be gen eralizable to other farming communities.

Conclusion

Farm injuries are a persistent cause of death and disability among adolescents. However, adolescence is also a key phase of life during which a lifetime of good habits and safety practices can be established. In support of the development of a gamified farm injury prevention resource for adolescents, qualitative insights from students and teachers at rural schools teaching agriculture were sought. Insights informed the development of "Calm Your Farm" and may prove useful for others looking to develop educational resources for adolescents.

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Data availability statement

Data are available upon reasonable request from the author at a.peden@unsw.edu.au.

Author contributions

AE conceptualised the study, was in charge of data curation and analysis, and wrote the first draft of the manuscript. DA assisted in review and editing of writing. TP assisted in the review of the manuscript. RI contributed to the conceptualisation and edited the manuscript. RF contributed to conceptualisation and assisted in data analysis and review of the manuscript.

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