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Transporting Children in Autonomous Vehicles: An Exploratory Study

Patrice D. Tremoulet, Rowan University, Glassboro, New Jersey, USA, **Thomas Seacrist**, **Chelsea Ward McIntosh**, **Helen Loeb**, Children's Hospital of Philadelphia, Pennsylvania, USA, **Anna DiPietro**, Rowan University, Glassboro, New Jersey, USA, and **Sophia Tushak**, Children's Hospital of Philadelphia, Pennsylvania, USA

Objective: Identify factors that impact parents' decisions about allowing an unaccompanied child to ride in an autonomous vehicle (AV).

Background: AVs are being tested in several U.S. cities and on highways in multiple states. Meanwhile, suburban parents are using ridesharing services to shuttle children from school to extracurricular activities. Parents may soon be able to hire AVs to transport children.

Method: Nineteen parents of 8- to 16-year-old children, and some of their children, rode in a driving simulator in autonomous mode, then were interviewed. Parents also participated in focus groups. Topics included minimum age for solo child passengers, types of trips unaccompanied children might take, and vehicle features needed to support child passengers.

Results: Parents would require two-way audio communication and prefer video feeds of vehicle interiors, seatbelt checks, automatic locking, secure passenger identification, and remote access to vehicle information. Parents cited convenience as the greatest benefit and fear that AVs could not protect passengers during unplanned trip interruptions as their greatest concern.

Conclusion: Manufacturers have an opportunity to design family-friendly AVs from the outset, rather than retrofit them to be safe for child passengers. More research, especially usability studies where families interact with technology prototypes, is needed to understand how AV design impacts child passengers.

Application: Potential applications of this research include not only designing vehicles that can be used to safely transport children, seniors who no longer drive, and individuals with disabilities but also developing regulations, policies, and societal infrastructure to support safe child transport via AVs.

Keywords: autonomous driving, children, parent decision making, vehicle design, intelligent vehicle systems, human–automation interaction

Address correspondence to Patrice D Tremoulet, Department of Psychology, Rowan University, 201 Mullica Hill Rd., Glassboro, NJ 08028, USA; e-mail: tremoulet@rowan.edu.

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BACKGROUND AND MOTIVATION

With the launch of ridesharing services such as Uber and Lyft, leasing a ride has become easy and inexpensive. Consequently, many parents are now relying on ridesharing services to shuttle their children across town (Niz, 2015; Schulte & Aratani, 2015). By itself, the acceptable age for an unaccompanied child to ride in a cab is an interesting question. With the 2016 launches of Uber's autonomous cabs in Pittsburgh and San Francisco, combined with automobile manufacturers stating that they anticipate offering vehicles with self-driving capabilities as soon as 2020 (Walker, 2018), this question becomes more intriguing: at what age can an unaccompanied child ride safely in an autonomous vehicle (AV)?

AVs have the potential to improve mobility of seniors who are no longer comfortable driving and individuals with disabilities (Chapman, 2017; National Highway Traffic Safety Administration [NHTSA], 2017; Nunes, Reimer, & Coughlin, 2018; Van Ort & Scheltes, 2017). If they can be used to transport passengers who are physically and/or cognitively unable to take control of the vehicles, then AVs could also be used to transport children (Haboucha, Ishaq, & Shiftan, 2017; Marshall, 2017; Phelan, 2017; Roberts, 2017; Sparrow & Howard, 2017). However, to date, there has been little research focused on ensuring that unaccompanied children can ride safely in AVs (Child Safety in a Self-Driving World, 2017; Lee & Mirman, 2018; Morris, 2017; Nooteboom, 2017; Schwebel, 2018; Silver, 2016). Meager consideration of children's needs is likely due to the large amount of attention being devoted to other topics related to AVs, such as ensuring that the technology underlying these vehicles is robust (Barabás, Todoruț, Cordoş, & Molea, 2017), confirming that AVs will actually be as safe or safer to use than traditional vehicles (Koopman & Wagner, 2017; Koopman & Wagner, 2018; Sivak & Schoettle, 2015), understanding how AVs will make decisions when preventing someone from harm is not possible (Bonnefon, Shariff, & Rahwan, 2016; Spangler, 2017), and understanding the impacts of AV technologies on infrastructure, economics, and society (Frey, 2017; Litman, 2018).

How can we ensure that children will be able to use AVs safely? Do AVs need special equipment to address unaccompanied children's needs? What sorts of knowledge and training about vehicle operation do passengers need? What factors should parents consider when deciding whether or not to allow a child to ride unaccompanied? What regulations should policy makers establish governing child use of AVs?

These questions highlight a vital need for research that can provide the scientific foundation for the specification of safety features, guidelines, and policies that will enable children to safely ride unaccompanied in AVs. Lee and Mirman's (2018) pioneering study represents an initial step toward developing this line of research. They conducted a nationwide survey of U.S. parents of 0- to 14-year-old children, which specifically asked about using AVs to transport children. They classified their participants into two broad categories, the curious, defined as "would like to try AV and embrace technology innovativeness," and the practical, defined as "had practical considerations . . . but saw the benefits of using AVs to transport children." This was the first study that focused particularly upon using AV to transport children, but this use case was previously mentioned by others (e.g., Haboucha et al., 2017; Harper, Hendrickson, Mangones, & Samaras, 2016; Kyriakidis, Happee, & de Winter, 2015; Sparrow & Howard, 2017).

In contrast to administering surveys, we conducted an exploratory study that entailed having parents, and some 8- to 16-year-old children, ride in a driving simulator in autonomous mode and then provide their opinions about using AVs to transport children. Prior research has shown that technology use is influenced by users' mental models or beliefs about the technology (Nielsen, 2010), and exposure to vehicle safety technology can influence those beliefs (Crump et al., 2016). The parents also participated in focus groups, where they were prompted to share their concerns about having their children ride unaccompanied in AVs and to help brainstorm possible ways to address those concerns through policies, training, and/or technology design. Our exploratory study, combined with the results of Lee and Mirman's (2018) survey, provides a good foundation for future research endeavors that will (a) help identify human factors requirements for the design and operation of AVs and (b) contribute to policies and standards for safe use of AVs by children.

METHOD

This research complied with the American Psychological Association Code of Ethics and was approved by the Institutional Review Board at Children's Hospital of Philadelphia (CHOP). Informed consent was obtained from each participant.

Recruitment

Twenty-one parents and 14 of their children were recruited using targeted emails, a posting on CHOP's research finder website, flyers posted outside CHOP's cafeteria, and snowball sampling (referrals from eligible participants). Two parents were not able to complete the full study; one was ineligible because she wore glasses and the other became too nauseous to finish the simulator session.

Driving Simulator

All simulator visits were completed in CHOP's Center for Injury Research and Prevention (CIRP)'s Realtime Technologies, Inc. (RTI) medium-fidelity, fixed-base driving simulator. To support the autonomous driving scenario, the driving simulator was integrated with SimDriver, an AV control simulation developed by RTI. Participants wore ASL Mobile Eye-XG eye tracking glasses, which recorded their focus while in the simulator.

Manual drive. Parent participants started with a 5-min introductory drive to become familiar with the simulator's displays and controls, including the lever that would engage and disengage autonomous mode and the emergency stop button. They then completed an 8-min manual drive that started on a city street, entered and exited a highway, and ended on a rural road. Directions such as "turn left" flashed on the screen to direct parents during the drive and a flashing stop sign appeared at the end to notify the parent the drive was over. Only parent participants completed the introductory and manual simulator drives. Parent participants who recently participated in another autonomous driving study using our simulator ($n = 6$) could elect to skip the introductory drive.

Autonomous drive. The autonomous drive lasted nearly 8 min. It was the reverse of the manual scenario: It started on the rural road, navigated to the highway entrance ramp, exited the highway onto a city street, and proceeded to the starting point of the manual drive. Both parent and child participants completed this drive using the simulator's autonomous mode. Participants were notified at the beginning of the autonomous drive that there were two locations (both left turns) where the autonomous mode might disengage, due to programming issues. In these instances (parent [$n = 14$], child [$n = 7$]), the simulation was stopped and restarted from the failure point.

Parent participants were reminded that pulling a left-hand lever, similar to flashing high beams, would engage and disengage autonomous mode, that the end of the drive would be indicated through a flashing stop sign, and that if they felt sick or had questions to let the experimenter know immediately. She then instructed them, "When you're ready, you may begin the drive by putting the car into drive and engaging self-driving mode."

For child participants, who were asked to sit in the back seat, away from the simulator's controls, the experimenter first explained that she would put the car in autonomous mode and start the drive and then told them that there would be a flashing stop sign and a message saying the drive was over at the end. Next, she reminded the children to tell her immediately if they felt sick or had any questions and asked them to tell her when they were ready for her to start the drive.

The drives contained hills, curves, straight areas, four-lane roads, and two-lane roads, with varying speed limit signs positioned along the roads. In addition, trees, houses, buildings, parked cars, a cyclist, and moving cars were included to simulate a mixture of rural and urban driving environments. Participants were not provided with use cases nor any explanation about why the vehicle would be going from the starting point to the end point to avoid influencing responses during postdrive interviews when they would be asked to describe scenarios for unaccompanied children riding in self-driving vehicles. However, parents were told prior to completing the autonomous drive that they were going to "do the same drive the opposite way, using self-driving mode."

The simulator visit portion of the study took approximately 60 min for parents and approximately 25 min for children. Parents experienced all drives while seated in the driver's seat of the driving simulator, and the children experienced the autonomous drive scenario while sitting in a vehicle seat positioned just behind the simulator driver's seat (like a back seat in a vehicle—see Figure 1).

Semi-Structured Interviews

After riding in the simulator in autonomous mode, the experimenter escorted participants to a small conference room and verbally administered structured interview questions, capturing responses with a digital audio recorder. All participants (parents and children) were asked whether they felt comfortable the entire ride, what the minimum age for children riding alone in AVs should be, where they imagine their children/themselves traveling to and from in AVs, whether the simulator ride was different from what they had expected—and if so how, and how they would expect to take control of an AV if necessary. Only parents were asked if they were tempted to take over control and if so when, if they would be comfortable riding in an AV with their children, and if they would be comfortable allowing their child to ride in an AV without an adult.

Focus Groups

Parents who successfully completed the driving simulator portion of the study were invited to return for a focus group discussion ($n = 19$).

Figure 1. Driving simulator "cab" with child seat positioned behind driver's seat.

Table 1 shares the numbers of participants who attended each focus group and Table 2 presents demographics for all participants.

We employed standard focus group methodology (Krueger & Casey, 2000) to elicit parents' thoughts about allowing children to ride unaccompanied in AVs because group interaction and cross-stimulation of ideas would likely foster discussion on this controversial topic. All focus groups were facilitated by trained researcher (T.S.), assisted by the principal investigator (P.T.), and lasted about 60 min. They started with a brief (5–10 min) presentation that was intended to ensure all participants had basic knowledge of AVs. The presenter first characterized and visually depicted the six different levels of autonomy designated by the Society of Automotive Engineers (SAE International, 2016), which entailed describing several existing advanced driver assistance systems, for example, forward collision warning, lane departure warning, and automatic emergency braking. Then, the presenter showed pictures of existing Level 2 vehicles (Toyota Prius, Tesla Model 3) and depictions of vehicles that will be at higher levels (e.g., Google self-driving car). Finally, the presenter briefly described the recent growth in ridesharing services and noted that both Lyft's and Uber's fleets include cars with self-driving capabilities.

Guided focus group topics included the following: What safety features for children would you expect AVs to have? What would you suggest as the minimum age for a child to ride alone in a regular taxi? In a driverless vehicle? When and where would you envision children using AVs most frequently? What communication features would you require for vehicles that carry children without adults (e.g., use audio or video to contact parents)? What sorts of AV status information would you request?

TABLE 1: Focus Group Participants

Focus Group	Females	Males	Total
1	6	1	7
2	5	2	7
3	3	2	5

Analysis Preparation

Audio recordings of interviews and focus groups were sent via secure online website to a transcription service, which de-identified all speakers. Due to the novelty of our research question and the limited relevant literature, we employed conventional content analysis methodology and adopted an inductive approach using open coding (Hsieh & Shannon, 2005).

Using a team-developed codebook, two members of our research team (A.D. and S.T.) used Excel to independently code the transcripts. All of the focus groups and 25% of the parent interviews were double coded to assess interrater reliability, which was above 90% for both. Saturation was reached by the final focus group, because no significant new topics were raised by the participants in response to the questions from the moderator guide.

RESULTS

Parent Interviews (n = 19)

Seventy-four percent of parents reported that the driving simulator was at least somewhat realistic. They reported that the roads and scenery, the accelerator, and brake pedals and the behavior of other motorists were realistic. However, 63% found turning to be unrealistic. When asked how riding in the simulator in autonomous mode differed from their expectations, responses were sometimes contradictory, for example, some said it was more realistic than anticipated and other said less, and some said it made them more nauseous than they expected, while others said they felt less nauseous than they anticipated. Other responses

TABLE 2: Participant Demographics

Participant	Females	Males	Total
Parents			
Total participants	14	5	19
Age range (years)	29–62	37–49	29–62
Mean age (years)	44.2 ± 8.6	43.2 ± 4.4	43.9 ± 7.6
Number of children			
1	3 (21.4%)	1 (20%)	4 (21.1%)
2	8 (57.1%)	3 (60%)	11 (57.9%)
3	2 (14.3%)	1 (20%)	3 (15.8%)
4	1 (7.1%)	0 (0%)	1 (5.3%)
Home setting			
City	40%	80%	50%
Medium town	26.7%	0%	20%
Small town	33.3%	20%	30%
Children			
Total participants	4	10	14
Age range (years)	8–15	8–16	8–16
Mean age (years)	11.3 ± 3.8	11.3 ± 2.6	11.3 ± 2.8

included expecting that it would feel more enclosed, that braking would be slower, and that they would need to take control more often.

While 79% of parent participants indicated that they felt comfortable and safe the entire time, 58% of them indicated that they had wanted to take over control at some point during the autonomous drive. They stated that they felt this urge when approaching stop signs or intersections, making turns, or slowing down. Parents indicated that if they needed to take control of an AV, they would push down on the brake, use the steering wheel, or push down the accelerator.

Sixty-three percent of parents indicated that they would feel comfortable driving a car with autonomous features either alone or with their child in the car. However, only 21% said they would be comfortable allowing their child to ride alone in an AV. When asked which method they would prefer to use to transport a child, 58% of the parents said public transportation, 26% said an AV, 11% said a taxi, and 5% said none of the options would be acceptable.

Child Interviews (n = 14)

Children reported that the scenery, behavior of other cars, and the overall driving experience were realistic, but nearly 30% said the graphics were unrealistic. When asked if they felt comfortable the entire ride, 79% said yes, 14% said no, and 7% said "I don't know." When asked how they would expect to take control of an AV, 33% of child participants said they would use the brake pedal, 33% said they would use a button "like one on school buses," and 21% said they would talk to the vehicle. Other responses were "use a key" and "grab the steering wheel." When asked if they would be comfortable riding alone in an AV, 50% said no, 36% said yes, 7% said maybe, and 7% said "I don't know." When they were asked whether they'd feel safest riding alone in a taxi, on public transportation, or in an AV, 57% said the AV, 36% said public transportation, and 7% said "none."

Focus Groups (n = 19)

Throughout this section, themes are listed in order of frequency of appearance in transcripts, from most to least, and frequencies are indicated in parentheses, for example, (f = 2). Note that transcripts do not differentiate among participants, so multiple mentions from the same person are counted as multiple remarks—but transcripts also do not capture head nods or other nonverbal cues indicating agreement with

TABLE 3: Minimum Ages That Parents Would Allow a Child to Be Alone in Different Situations

Solo Child	Stay Home	Ride Bus or Train	Ride in Taxi	Ride in AV
Range	8–13	12–16	10–13	8–18
Mode	11 (f = 10)	13 (f = 8)	13 (f = 8)	16 (f = 9)

Note. AV = autonomous vehicle.

other participants' comments. Focus groups started with a discussion about the *minimum age* at which a parent would allow a child to stay home alone, followed by the minimum ages that they would allow them to use different forms of transportation. Ranges and modes for the different scenarios are shown in Table 3. In each focus group, at least one parent stipulated that it "depends on the child," explaining that some children can be trusted to make better decisions much younger than others (f = 9).

Most parents would let children ride alone in public transportation or taxis at a younger age than in an AV, but one parent said she would allow an 8-year-old to ride in an AV alone. (The next lowest age given by other parents was 15.) Many parents indicated they believed that children riding alone in AVs would need to be able to physically take over control of a vehicle using conventional controls (f = 5). However, some parents were also concerned about young children not behaving or not interacting appropriately with AVs (f = 3).

When the moderator asked what sorts of *knowledge and skills* children should possess before being allowed to ride alone in an AV, the two most frequently cited items were "ability to make good decisions" (f = 6) and "level of competence needed to obtain driver's license" (f = 5). Other responses included "knowing what to do to take over" (f = 4), "knowing how to use features in the vehicle" (f = 2), "ability to use cell phone to dial 9-1-1" (f = 2), "understanding of emergency protocol" (f = 2), and "rules of the road" (f = 1).

Communication features that the parent participants said they would want in an AV used to transport children include the ability to call or establish a video link with passengers (f = 7) and the ability to submit an "emergency contact list" of people who would be notified if an unplanned event impacts a child's trip (f = 4). Some parents mentioned that AVs should automatically notify first responders in case of an accident or carjacking attempt (f = 3). The technology advances needed to support these features is already being investigated (Weil, 2017).

Safety features desired by parents include an emergency stop switch (f = 4), verification that seatbelts are fastened and assistance fastening seatbelts (f = 3), "intruder alerts" that notify adults outside the vehicle if someone tries to enter a vehicle (f = 3), cyber security to prevent hacking controls or live video feeds (f = 3), a safety lock that prevents children from switching the vehicle from autonomous to manual operation (f = 2), a security system that can verify passenger identity (f = 2), automatic door locks once children are inside (f = 2), and a black box that records drive events including controls and passenger actions (f = 1).

Desired *parental control features* include only allowing parents to set destinations or seeking parental permission if a child requests a destination change or stop along the way (f = 7), automatically notifying parents when a child has arrived at a destination (f = 4), permitting parents to require vehicles NOT stop for fuel or food/bathroom breaks (f = 3), and allowing parents to remotely change settings such as temperature and radio (f = 1). Some parents would want AVs to notify child passengers of any issues impacting a trip and suggest solutions to them (f = 3), whereas others preferred that solutions only be presented to a parent or emergency contact (f = 2).

Parents also indicated they would want to be able to *remotely access trip and vehicle information* via secure login (f = 3). Types of information mentioned include diagnostic reports; maintenance records; current speed, location, and traffic/weather conditions; time since child entered vehicle; miles traveled; and condition of emergency supplies (e.g., first aid kit, blankets, water).

Parents identified five *use cases* for transporting children in AVs: traveling to/from social activities (e.g., a friend's house, shopping mall); shuttling from school to off-site extracurricular activities; traveling between home and sports activities; moving between school, work, and home; and emergency pick-up/transport.

Parents indicated that the following *factors would influence their decisions about whether or not to allow an unaccompanied child to use an AV*: weather conditions ($f = 8$), recalls/maintenance issues ($f = 7$), child functional age/maturity level ($f = 5$), travel distance ($f = 5$), time of day ($f = 3$), whether vehicle is owned or being leased for a ride ($f = 2$), child's needs to get out during the trip ($f = 2$), presence/absence of other children ($f = 2$), recent accidents for a particular make/model of vehicle ($f = 1$), body of evidence on AV safety ($f = 1$), and numbers of autonomous versus traditional cars on the road ($f = 1$). Two parents in different focus groups indicated that they would not be comfortable allowing an unaccompanied child to ride in an AV without supportive societal infrastructure, for example, a ground version of air traffic control, and previously designated safe havens, where an AV would go if something prevented it from delivering a child to the originally specified destination.

At the end of the focus groups, the facilitator asked parents what they perceive as the greatest benefit of AVs and what concerns them the most about AVs. The benefit cited most often was "convenience" ($f = 6$). Other benefits mentioned were more flexibility ($f = 3$), increased safety ($f = 3$), a viable transportation solution in emergencies ($f = 2$), and more time to interact with children rather than just drive them ($f = 1$).

The most frequently cited concern about using AV to transport children was that passengers' safety might be compromised if vehicles could not protect them after an accident or if the vehicle had a mechanical problem and could not continue the trip ($f = 6$). Three parents mentioned that they were concerned about AVs being cyber-hijacked and routed to new destinations.

DISCUSSION

Many of our findings are consistent with a recent survey asking U.S. parents about using AVs to transport children (Lee & Mirman, 2018), though there are several important differences. Parents in both studies indicated that AVs used to transport children should supervise the use of restraints and enable parents to use audio and/or video to communicate with child passengers. Both groups also indicated that it would be important to have a support infrastructure; the survey respondents focused upon children needing the infrastructure at the beginning and ending of trips, whereas parents in our study indicated that a support infrastructure would be needed in case of unplanned trip interruptions. In addition, both groups of parents indicated that they would be more likely to use an AV to transport their children if other children were in the vehicle.

Parents in both studies cited increased safety and quality time for parents to interact with children as benefits of AVs. Moreover, several benefits suggested in Lee and Mirman's survey are related to convenience, which was the benefit that our participants mentioned most often (e.g., avoiding stressful or boring drives and staying home to work, rest, or relax). However, the parents in our study never mentioned cost, but it was a significant concern for the survey respondents. Parents in both studies indicated that their biggest concern was that AVs might not be able to adequately protect their children; both also mentioned lack of trust in AV technology and privacy and security concerns. Survey respondents indicated that they would be uncomfortable giving up control of the vehicles transporting their children, whereas some of our participants reported concerns about their children's interactions with AVs, for example, trying to redirect the AV or allow others to enter without securing parent consent ($f = 5$), removing seatbelts ($f = 4$), and pressing buttons out of curiosity ($f = 3$).

While Lee and Mirman described their parents as "curious" or "practical," we would characterize the parents in our study as "eager," for example, "it definitely would be ideal and efficient and effective for parents getting kids places" and "I think it's going to be so much safer than driving once it works" or "reluctant/opposed," for example, "I don't think we're ready to be the Jetsons . . . it doesn't seem realistic yet" and "I'm a late adopter of new technologies, and it would be even later with my kids." Moreover, as we only included parents of 8- to 16-year-old children, our parents did not have concerns about child restraint systems or children exiting from vehicles. Finally, our finding that only one-third of the parents in our study who indicated they would be comfortable having their child ride with them in an AV also said that they would be comfortable allowing their child to ride alone in an AV is consistent with another prior survey (Tardo, 2015).

One of the strengths of our approach was providing participants with substantial context about AVs; we had all participants ride in a driving simulator in autonomous mode and began our parent focus groups with an informational briefing about technologies underlying AVs and SAE's six levels of vehicle automation. In addition, as all participants came to our site, we were able to monitor their engagement and attention while conducting the study. However, we did not intentionally expose our participants to a situation where the vehicle behaved unexpectedly (e.g., drifted out of its lane or failed to swerve around an obstacle in the road). It is possible that fewer of our parents would have indicated they would be comfortable letting their child(ren) ride alone in an AV if we had included these situations in our study. Moreover, because our method is relatively labor intensive, we only had a small number of participants. Additional benefits, concerns, and use cases might have been identified if more parents and children had been able to participate. Finally, as our driving simulator included traditional manual controls even when it was used in autonomous mode, some of our results may not be relevant to manufacturers who are planning to deploy vehicles without these controls (brake/accelerator).

CONCLUSION

Automobile manufacturers whose roadmaps include AVs must consider the variety of possible uses for these vehicles, including passengers with no driving experience, such as adults with disabilities and children below the age of 16 years. Based upon input from parents who had experienced autonomous driving via a simulator, we believe that features that enable passengers to communicate with remote trusted authorities, who can either authorize passengers to reprogram a trip or remotely reprogram the trip, will be important to families' adoption and use of AVs. However, contributions from many other stakeholders besides manufacturers are needed to ensure that unaccompanied children will be able to ride safely in AVs (Davidson & Spinoulas, 2015; Lee & Mirman, 2018; Litman, 2018). Moreover, while child passengers have some unique needs, they share many needs with other potential beneficiaries of AVs: adults with disabilities and nondisabled seniors who have given up driving. Legislators, transportation planners, city/regional/state planners, and representatives from public service and public safety organizations need to work with vehicle manufacturers, parents, and advocates for seniors and individuals with disabilities to establish policies, usage standards, requirements, and best practices for AV use, including passenger training programs, "safe havens," and other infrastructure supports for vulnerable passengers.

Additional research is needed to inform those stakeholders. More exploratory work is needed to flesh out the five use cases for unaccompanied children riding in AVs that our study identified. Usability studies, in which families interact with technology prototypes, are needed both to explore how unaccompanied children might interact with AVs and to better understand how parents would interact with AVs transporting their children, using mock-ups of some of the communication and information access features that parents in our study mentioned. In addition, input from not just parents but also seniors and disability advocates is needed to robustly specify the infrastructure supports needed to enable AVs to safely transport passengers who may need assistance getting secured into vehicles, exiting from them, and/or during unplanned trip interruptions. In short, our results are only a starting point; a variety of additional research efforts are needed to produce more of the information required to ensure that AVs will be designed to support safe travel for *all* passengers.

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KEY POINTS

- As AVs become more common, many parents will want the option to use them to transport unaccompanied children.
- Contributions from a wide range of stakeholders, including policy makers; urban, regional, and state planners; transportation experts and public service and public safety organizations; as well as parents and vehicle manufacturers, are needed to enable use of AVs to safely transport children.
- All of these stakeholders would benefit from more research focused on child and family use of AVs.
- Children are good surrogates for understanding what vehicle features and infrastructure supports are needed to safely transport disabled/handicapped adult potential passengers, though there are some unique needs for child transport related to parental monitoring and control.

ORCID iDS

Patrice D. Tremoulet https://orcid.org/0000-0003-0443-9806

Chelsea Ward McIntosh https://orcid.org/0000-0002-7246-4379

SUPPLEMENTAL MATERIAL

The online supplemental material is available with the manuscript on the *HF* website.

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Patrice D. Tremoulet is a professor of human factors psychology at Rowan University. She received her PhD in cognitive psychology from Rutgers University in 2000.

Thomas Seacrist is a project manager for engineering research at the Center for Injury Research and Prevention in the Children's Hospital of Philadelphia Research Institute. He earned his MS in biomedical engineering from the Catholic University of America in 2007.

Chelsea Ward McIntosh is the neuroscience of driving program manager at Children's Hospital of Philadelphia. She earned her MS in psychology from Rivier University in 2011.

Helen Loeb is a research engineer in the Center for Injury Research and Prevention at the Children's Hospital of Philadelphia, and the CEO of Jitsik, LLC. She earned her PhD in robotics from the University of Bordeaux in 1996.

Anna DiPietro is the research manager of the Rowan University Interaction Design and Engineering for Advanced Systems (IDEAS) laboratory. She earned her BS in psychological science from Rowan University in 2018.

Sophia Tushak is a mechanical engineering graduate student at the University of Virginia. She earned her BS in biomedical and health sciences engineering from the University of North Carolina/North Carolina State University in 2018.

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