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Short Note

Perceived Effectiveness of Messages Designed to Promote the Use of Autonomous Vehicles

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Abstract Autonomous vehicles will be a key component of the sustainable cities and transport systems of the future. However, there is little data available on effective methods of communicating with the public about these benefits to optimise uptake and achieve their sustainability potential. The aim of this exploratory study was to assess outcomes associated with exposure to various messages communicating proposed benefits of autonomous vehicles. Australians aged 16+ years (n = 1053) responded to two online surveys administered two weeks apart. The instruments included items relating to demographic attributes, driving factors, and attitudes to autonomous vehicles. Respondents were randomised to one of five messages referring to efficient travel time, economic savings, saving lives, mobility for the elderly and disabled, and job opportunities. Messages relating to saving lives and providing mobility for the elderly and disabled performed best, especially in terms of presenting a strong argument (62% agreement) and believability (67% agreement), respectively. The results provide initial evidence that public awareness communications could favourably influence attitudes to autonomous vehicles, potentially enhancing uptake rates to yield corresponding benefits. This information will be of value in countries where the roll-out of autonomous vehicles is a strategic priority to achieve sustainable cities and transport systems.

Keywords autonomous vehicles; transport; attitudes; communication

1. Introduction

Autonomous vehicles (AVs) are forecast to bring a diverse range of benefits across environmental and social domains [1–6]. More sustainable cities and transport systems resulting from AVs are anticipated through a reduction in crash-related injury and death, enhanced safety for pedestrians and cyclists, greater mobility for the elderly and disabled, increased leisure time, reduced pollution, and new skilled employment opportunities. Anticipated potential disbenefits include potential increased traffic congestion due to empty vehicles on the roads, job losses in traditional driving-related professions, increased suburban sprawl, greater sedentarism, and losses in privacy. Reviews have concluded that net sustainability and social benefits are likely to substantially outweigh negative outcomes if AVs are implemented soundly, and hence that efforts should be made to facilitate their timely and well-planned introduction [7–13].

While the widespread use of fully autonomous vehicles is likely to take decades [3,14], hundreds of AV trials are in place around the world, including "robo-taxi" fleets in some US cities [15]. The speed with which the benefits of AVs could be realised will be influenced by the rate of public acceptance and adoption [16,17]. However, many potential users exhibit unwillingness to use AVs due to a range of concerns, especially safety-related fears [18–20].

Communications theories note the importance of increasing awareness and knowledge to produce changes in attitudes and preferences [21]. This highlights the need to identify effective methods of communicating with members of the general public to increase awareness of potential benefits from AVs [8]. Research from the US, India, and China indicates that positively framed messages can increase willingness to ride in AVs [22,23], however the specific AV-awareness messages that would be most acceptable and effective are unknown [24]. Further work across a broader range of cultural contexts is needed to understand which forms of messaging may favourably influence attitudes to AVs. This work can inform the development of communications that may assist in optimising uptake rates once the technology is widely available, bringing sustainability benefits closer to realisation [5,25,26].

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The aim of this exploratory study was to assess community responses to a range of potential messages to determine which are most likely to resonate with the general public and various population sub-groups. The study context was Australia, where previous research has identified diverse attitudes to AVs across the population [27,28]. The sections below outline the methodological approach adopted for this study, the results in relation to individual tested messages and comparisons across messages, and an interpretation of the results in the context of previous research.

2. Materials and Methods

As part of a larger study, ethics approval was obtained from a University Human Research Ethics Committee to conduct two online surveys to gauge public opinion about the potential benefits and disbenefits of AVs. An ISO-accredited web panel provider (Pureprofile) was commissioned to recruit a sample of Australians aged 16+ years, with quotas applied to produce a sample with an equal gender split and approximately even distribution between age (16–30, 31–50, 51+ years) and socioeconomic (low, mid, high) groups.

The two surveys were administered two weeks apart. The first survey instrument included items relating to demographic attributes (age, gender, postcode (for socioeconomic position derivation)), driving factors (driving status, enjoyment of driving, crash history), and subjective knowledge about and attitudes to AVs. The subjective knowledge question asked respondents to report how much they know about AVs (4-point scale "Nothing at all" to "A large amount"). The attitudinal items included (i) a question on feelings about AVs being widely used in the future (5-point scale "Very negative" to "Very positive"), (ii) a bank of 13 anticipated positive outcomes (e.g., crash reduction, increased fuel efficiency, fewer emissions, and lower insurance rates: 5-point scales "Very unlikely" to "Very likely"), and (iii) a bank of 13 anticipated negative outcomes (e.g., system/equipment failure, loss in human driving skills, privacy risks, and liability issues: 5-point scales "Extremely concerned" to "Not at all concerned" [29]). At the end of the first survey, respondents were randomised to one of five messages covering a diverse range of AV-related topics that have been previously identified as being of potential interest or concern to the public [18,27]. The tested messages are shown in Figure 1.

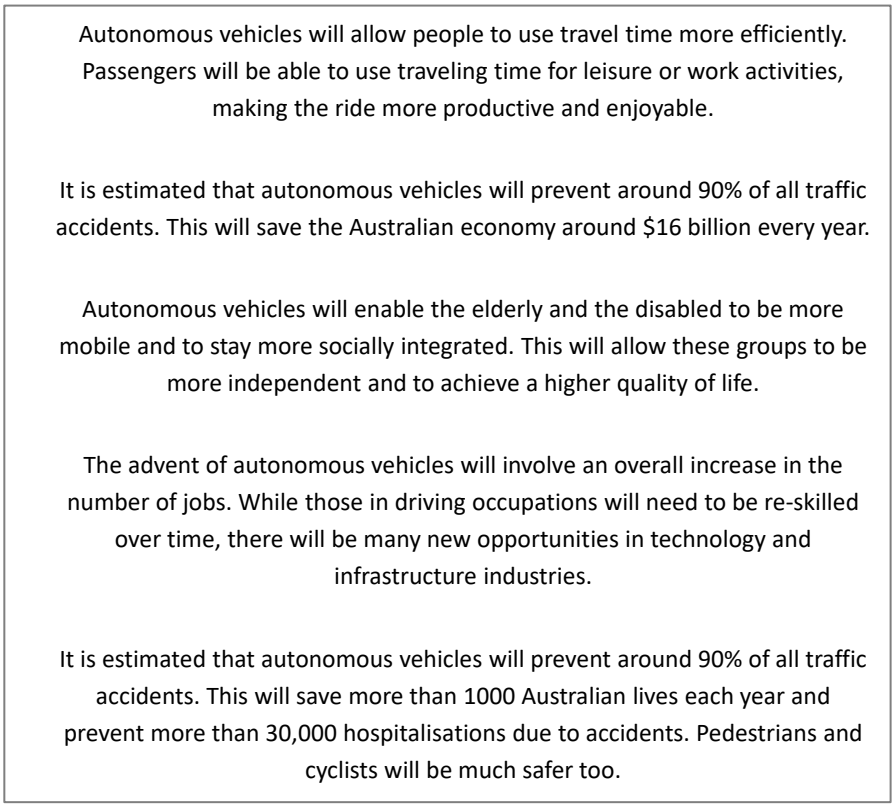

Figure 1. Tested messages.

The gap of two weeks between the surveys permitted message recall to be assessed. In the second survey, respondents were asked if they could recall the message they were shown in the previous survey and to report the recalled message. They were then shown the message as a reminder and asked to complete a perceived message effectiveness scale (based on a scale used for testing tobacco control messages) [30]. The scale included items relating to the extent to which audience members perceive the message to be believable, personally relevant, presenting a strong argument, teaching something new, capable of making one stop and think, and motivating (5-point scales: "Strongly disagree" to "Strongly agree").

3. Data Analysis

The messages were assessed on each of the perceived effectiveness criteria and a composite score representing the average of all six criteria, with comparisons conducted using ANOVA analyses. Bivariate correlation analyses were undertaken to assess which of the demographic, driving-related, subjective knowledge, and/or attitudinal variables were associated with the perceived effectiveness composite score for each message. Variables with significant results were then included in multiple linear regression analyses to identify factors associated with higher perceived effectiveness scores for each message and across all five messages.

4. Results

Of the respondents participating in the present study, 1353 completed the initial survey and 1053 completed both surveys (22% attrition rate). The demographic attributes of those completing both surveys are listed in Table 1. When controlling for multiple comparisons, only age was significantly different between respondents who withdrew after the Time 1 survey and those who did not (mean age 36 vs 45 years, $p < 0.001$). On average, 211 respondents were allocated to each message in the final sample, with no significant demographic differences found between groups (see Figure 2 for distribution by message).

Table 1. Sample profile of respondents completing both surveys (n = 1053).

Demographic Attribute	*n*	Present Study (%)	Australian Population [a] (%)
Gender			
Female	513	49	51
Male	540	51	49
Age			
Mean (*SD*)		44.8 (17.6)	N/A
16–30 years	292	28	24
31–50 years	360	34	34
51+ years	401	38	42
Socioeconomic status [b]			
Low	329	31	38
Mid	481	46	41
High	241	23	21
Missing [c]	2	0.2	N/A
Education			
Tertiary	383	36	31
Non-tertiary	670	64	69

Note: Proportions may not add up to 100% due to rounding. N/A = not available.
[a] Percentages for age and gender are from Australian Bureau of Statistics census data [31]. Percentages for education are based on the Australian Bureau of Statistics Education and Work data cubes for persons aged 20 to 64 years [32].
[b] Taken from Australian Bureau of Statistics Socio-Economic Indexes for Areas (SEIFA) classification data [33].
[c] Treated listwise.

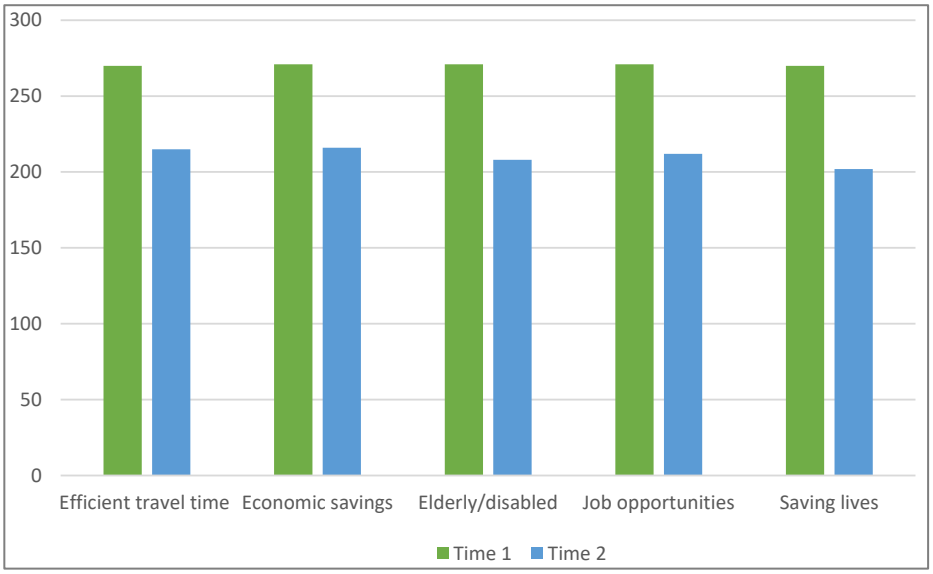

Figure 2. Number of respondents assigned to each message at Time 1 and Time 2.

The recall rate was 24% across all messages, ranging from 21% for the economic savings message to 27% for the job opportunities message (see Figure 3). The perceived effectiveness results based on responses from those assigned to the message conditions (n = 1053) are shown in Table 2. The highest levels of agreement were found for the criteria of believability and presenting a strong argument: around two-thirds of respondents agreed that the elderly/disabled message was believable (67%) and that the saving lives message presented a strong argument (62%). The job opportunities message exhibited the lowest composite score and the lowest mean score on all individual criteria.

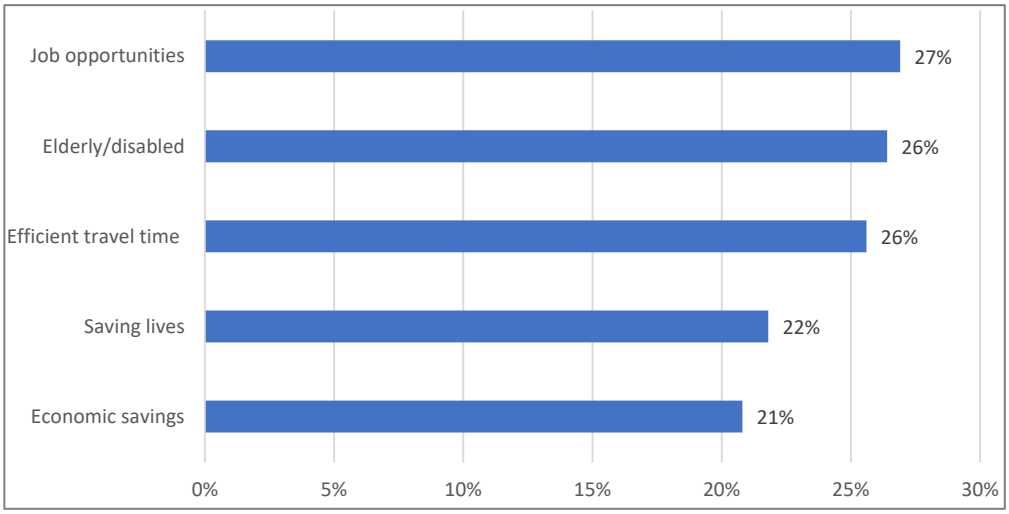

Figure 3. Percentage of respondents recalling each message.

Table 2. Perceived effectiveness of messages.

	Efficient Travel Time Message (*n* = 215)		**Economic Savings Message (*n* = 216)**		**Elderly/ Disabled Message (*n* = 208)**		**Job Opportunities Message (*n* = 212)**		**Saving Lives Message (*n* = 202)**		**Average of All Messages (*n* = 1053)**		**Overall Model**
Perceived effectiveness scale variables ^													
	M (SD)	%	M (SD)	%	M (SD)	%	M (SD)	%	M (SD)	%	M (SD)	%	
Believability	3.5 (0.98) ^{a,b}	56	3.2 (1.15) ^{a,c}	47	3.7 (0.86) ^{b}	67	3.1 (1.01) ^{c}	44	3.2 (1.02) ^{c}	44	3.4 (1.03)	52	$F(4, 1048) = 12.10$ $p < 0.001$
Relevance	3.0 (1.15) ^{a}	39	3.2 (1.09) ^{a,b}	40	2.9 (1.13) ^{a}	33	2.5 (1.06) ^{c}	20	3.3 (0.99) ^{b}	48	3.0 (1.12)	36	$F(4, 1048) = 16.37$ $p < 0.001$
Stop and think	3.3 (1.06) ^{a,b}	48	3.4 (1.10) ^{a,b}	55	3.4 (0.92) ^{a,b}	54	3.2 (1.02) ^{a}	43	3.5 (1.02) ^{b}	57	3.4 (1.03)	51	$F(4, 1048) = 2.54$ $p = 0.039$
Strong argument	3.3 (1.08) ^{a,b}	47	3.5 (1.18) ^{b,c}	57	3.6 (1.01) ^{c}	59	3.1 (1.05) ^{a}	38	3.6 (1.12) ^{c}	62	3.4 (1.12)	52	$F(4, 1048) = 9.73$ $p < 0.001$
Taught something new	3.1 (1.03) ^{a}	38	3.4 (1.08) ^{b}	54	3.3 (0.93) ^{a,b}	43	3.1 (1.07) ^{a}	41	3.4 (1.03) ^{b}	53	3.3 (1.04)	46	$F(4, 1048) = 4.74$ $p < 0.001$
Increased motivation	2.9 (1.12) ^{a,b}	35	3.1 (1.11) ^{a,b}	33	3.1 (1.09) ^{a}	38	2.8 (1.08) ^{b}	26	3.1 (1.10) ^{a}	37	3.0 (1.12)	34	$F(4, 1048) = 3.47$ $p = 0.008$
Composite	3.2 (0.90) ^{a,b}	-	3.3 (0.97) ^{a}	-	3.3 (0.80) ^{a}	-	3.0 (0.81) ^{b}	-	3.3 (0.90) ^{a}	-	3.2 (0.89)	-	$F(4, 1048) = 7.22$ $p < 0.001$

^ Percentages represent proportions of respondents allocated to the message selecting 4 or 5 on a 5-point "Strongly disagree" to "Strongly agree" scale.
Note: Values within each row that have different superscript letters are significantly different to each other as per ANOVA analyses.

In the bivariate analyses examining factors associated with perceived message effectiveness, six factors were consistently associated with the composite effectiveness scores across the five messages: age, socioeconomic position, average score for the potential positive outcomes, average score for the potential negative outcomes, subjective knowledge regarding AVs, and feelings about AVs being widely used in the future. In the multiple regression analyses, four of these variables were significant at the aggregate level across the five messages: feelings about the wide-scale use of AVs in the future ($\beta = 0.41$), anticipated positive outcomes ($\beta = 0.23$), age ($\beta = -0.09$), and socioeconomic position ($\beta = 0.06$) (Table 3). Results varied somewhat for individual messages; for example, age was only significant for two messages (job opportunities and efficient time use while travelling) and socioeconomic position was only significant for one message (efficient time use while travelling).

Table 3. Regression results: factors associated with perceived message effectiveness (n = 1053).

	Efficient Travel Time		**Economic Savings**		**Elderly/Disabled**		**Job Opportunities**		**Saving Lives**		**All Messages**	
Factor	B [95% CI]	β	B [95% CI]	β	B [95% CI]	β	B [95% CI]	β	B [95% CI]	β	B [95% CI]	β
Age	<0.01 [−0.01, <0.01]	−0.13 *	<0.01 [−0.01, <0.01]	−0.11	<0.01 [<−0.01, <0.01]	<0.01	<0.01 [−0.01, <0.01]	−0.19 **	<0.01 [<−0.01, <0.01]	0.02	<0.01 [−0.01, <0.01]	−0.09 **
Socioeconomic status	0.14 [0.03, 0.26]	0.13 *	0.06 [−0.07, 0.19]	0.05	0.01 [−0.10, 0.12]	0.01	0.10 [−0.01, 0.21]	0.10	−0.01 [−0.13, 0.11]	−0.01	.06 [0.01, 0.11]	0.06 *
Av. of anticipated positive outcomes	0.30 [0.17, 0.43]	0.33 ***	0.27 [0.15, 0.39]	0.27 ***	0.15 [0.04, 0.25]	0.19 **	0.09 [−0.01, 0.20]	0.12	0.34 [0.22, 0.47]	0.36 ***	0.21 [0.15, 0.26]	0.23 ***
Av. of anticipated negative outcomes	0.05 [−0.04, 0.14]	0.06	−0.07 [−0.14, 0.03]	−0.08	0.03 [−0.06, 0.12]	0.04	0.03 [−0.05, 0.12]	0.05	−0.04 [−0.14, 0.07]	−0.04	<0.01 [−0.04, 0.04]	<0.01
Subjective knowledge	0.05 [−0.11, 0.20]	0.04	0.21 [0.04, 0.38]	0.14 *	−0.08 [−0.23, 0.07]	−0.06	−0.01 [−0.14, 0.12]	−0.01	−0.03 [−0.18, 0.11]	−0.03	−0.01 [−0.06, 0.08]	<0.01
Feelings about widespread AV use in the future	0.25 [0.13, 0.36]	0.30 ***	0.36 [0.24, 0.48]	0.39 ***	0.34 [0.24, 0.43]	0.47 ***	0.36 [0.27, 0.45]	0.49 ***	0.36 [0.25, 0.48]	0.41 **	0.34 [0.29, 0.39]	0.41 ***
Overall model	R^2 = 0.39, F(6, 207) = 22.14, p < 0.001		R^2 = 0.37, F(6, 209) = 20.45, p < 0.001		R^2 = 0.33, F(6, 201) = 16.60, p < 0.001		R^2 = 0.38, F(6, 205) = 20.66, p < 0.001		R^2 = 0.42, F(6, 194) = 23.14, p < 0.001		R^2 = 0.34, F(6, 1044) = 87.77, p < 0.001	

* p < 0.05, ** p < 0.01, *** p < 0.001

5. Discussion

This study contributes to the very limited body of literature examining how attitudes to AVs may be enhanced through communication campaigns [22,23]. The results are important due to the demonstrated role of attitudes to AVs in determining adoption intentions [34]. By generating information on how members of the general public respond to AV-promoting messages, the results of the present study provide policy makers and practitioners with specific insights into potential messaging approaches.

The strongest performing messages in terms of perceived effectiveness were those relating to saving lives, mobility for the elderly/disabled, and economic savings. As well as exhibiting the highest composite score, the saving lives message displayed the highest scores across three of the perceived effectiveness variables: strong argument, stop and think, and personal relevance. The elderly/disabled message had the highest agreement levels for two of the remaining variables (believability and motivation). These results suggest that messages relating to the ability of autonomous vehicle technology to save lives and improve the quality of life for the elderly and disabled may be the most acceptable and effective in the Australian context. They may therefore represent important topics to consider in communication strategies designed to enhance community receptiveness to AVs. The ability of one in four respondents to recall their allocated message after a single exposure indicates the potential for communications about AVs to achieve cut-through.

The regression results highlight the importance of pre-existing attitudes to AVs in influencing reactions to AV-promoting messages. This reflects the emphasis in the Technology Acceptance Model on the role of prior expectations in determining adoption levels [35], and is consistent with the transtheoretical model of behaviour change that posits individuals can be at various levels of readiness to adopt a new behaviour, which in turn affects their receptivity to information about that behaviour [36]. The relative importance of favourable anticipated outcomes highlights the need for AV-promoting messages to explain the specific benefits that can accrue from AVs to provide tangible positive reasons for endorsement and adoption.

The tendency for younger respondents to react more favourably to the messages is consistent with previous research indicating that this group is likely to be more accepting of AVs [37,38], and suggests that they represent key initial target audiences for AV-promoting messages. Increasing uptake among younger cohorts could have positive population-level outcomes due to the important role of observation of others' use of new innovations in encouraging broader adoption [39]. As has been seen in the case of other technology-related innovations (e.g., smartphones and ride-sharing services), initial rapid uptake by younger cohorts can quickly spread to older age groups [40,41].

The lack of gender and education effects in respondents' reactions to the messages was unexpected given prior evidence that these sociodemographic attributes are associated with attitudes to AVs [37,38], including in Australia [27]. This outcome indicates that factors contributing to pre-existing attitudes are somewhat different to those influencing individuals' responses to AV-promoting messages. This is a potentially favourable outcome because it suggests that communication campaigns designed to prepare the public for the introduction of AVs could serve to overcome existing variations in attitudes to AVs among some population subgroups.

6. Study Strengths and Limitations

An important strength of the present study was the novel application of a rigorous message testing process in the AV context. The inclusion of two waves of data collection permitted assessment of message recall, overcoming issues relating to cross-sectional approaches. In addition, the Australian context of the study provides an alternative location to the previous AV message testing research undertaken in the US, India, and China [22,23].

A primary limitation of this study was the reliance on a web panel, which may have produced a skew towards more technologically savvy respondents. Second, a definition of AVs was not provided to respondents, possibly resulting in different respondents visualising different forms of AV implementation. For example, attitudes to AVs are likely to differ considerably depending on whether they are expected to be introduced in the form of privately-owned or shared vehicles [28]. Third, respondents' exposure to just a single viewing of the message prior to the assessment of recall constitutes a further limitation. Education campaigns typically rely on multiple exposures to achieve desired outcomes [42]. Fourth, the 22% attrition rate between survey waves and higher attrition among younger respondents may have skewed the results. A final limitation was

the confinement of data collection to a single country. Future research could replicate this work elsewhere to ascertain the extent to which the results apply in other countries where the roll-out of autonomous vehicles is a strategic priority. Future research could also assess a broader range of messages reflecting increasing understanding of the potential benefits of AVs. For example, ethical attitudes relating to the use of artificial intelligence, cybersecurity, and privacy and to the required infrastructure adaptations are also likely to impact on individuals' support for the widespread implementation of AVs [43,44].

7. Conclusion

The results of this study provide initial evidence that specific AV-promoting messages may be considered believable and informative by the general public. Messages relating to the life-saving potential of AVs, their ability to improve the lives of the elderly and disabled, and possible economic savings appear to be especially worthy of further investigation. The development and dissemination of such messages could constitute one element of a comprehensive program of work designed to increase uptake of AVs once they are available to optimise potential sustainability benefits.

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Data Availability

Data are unavailable due to ethics approval conditions.

Author Contributions

Conceptualization: S.P.; Formal analysis: L.B.; Funding acquisition: S.P.; Writing – original draft: S.P., & L.B.; Writing – review & editing: S.P., & L.B.

Conflicts of Interest

The authors have no conflict of interest to declare.

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