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Comfort and Attitudes Towards Robots Among Young, Middle-Aged, and Older Adults: A Cross-Sectional Study

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Abstract

Purpose: To explore the social impact of, comfort with, and negative attitudes towards robots among young, middle-aged, and older adults in the United States.

Design: Descriptive, cross-sectional. Conducted in 2014–2015 in an urban area of the western United States using a purposive sample of adults 18 years of age or older.

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Methods: Respondents completed a survey that included the Negative Attitudes Toward Robots Scale (NARS) and two questions taken or modified from the European Commission's Autonomous System 2015 Report. Analyses were conducted to compare perceptions and demographic factors by age groups (18–44, 45–64, and ≥65 years).

Findings: Sample included 499 individuals (n = 322 age 18–44 years, n = 50 age 45–64 years, and n = 102 age 65–98 years). There were no significant differences between age groups for 9 of the 11 items regarding social impact of robots and comfort with robots. There were no significant differences by age groups for 9 of the 14 items in the NARS. Among those items with statistically significant differences, the mean scores indicate similar sentiments for each group.

Conclusions: Older, middle-aged, and younger adults had similar attitudes regarding the social impact of and comfort with robots; they also had similar negative attitudes towards robots. Findings dispel current perceptions that older adults are not as receptive to robots as other adults. This has implications for nurses who integrate supportive robots in their practice.

Clinical Relevance: Nurses working in clinical and community roles can use these findings when developing and implementing robotic solutions. Understanding attitudes towards robots can support how, where, and with whom robots can be used in nursing practice.

Keywords

aged; attitude; middle aged adult; robotics; older adult; young adult

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Robots are being developed for people of all ages and for settings ranging from the clinic to the home and the community. They provide healthcare assistance (Pearce et al., 2012; Pollack et al., 2002; Prakash et al., 2013; Prakash, Kemp, & Rodgers, 2014), support various activities of daily living (Prassler, Ritter, Schaeffer, & Fiorini, 2000), and provide companionship (Broekens, Heerink, & Rosendal, 2009). Given nursing's role in supporting individuals' healthcare, activities of daily living, and psychosocial needs, nurses will likely lead in the implementation and adoption of robotic technologies to support patient care.

Nurses can facilitate integration of robotic technologies into patient care by understanding patients' attitudes towards robots. Individuals' attitudes about technology and perceptions of a technology's usefulness can impact their acceptance and use, which may impact the success of nursing interventions using robotic technologies. The Technology Acceptance Model (TAM) proposes that an individual's perceptions about a technology can impact their decision about its use (Venkatesh & Davis, 2000). This model suggests that in order to successfully use robotic technologies to support patients, nurse scientists and practicing nurses will need to understand patients' attitudes about robots to develop or deploy nursing interventions using robots.

To more effectively develop use of robotic technologies to support patient health, nurse scientists and practitioners could also benefit from an increased understanding of whether attitudes differ by population. This is especially important when working with older adults, who are often considered a population that requires tailored introduction of robots. Older adults are perceived of as being wary of technology (Weiss, Beer, Shibata, & Vincze, 2014). However, when older adults were asked about their perceptions, they were open to new robotic technologies (Beer et al., 2012; Broekens et al., 2009; Smarr et al., 2014) and may be more accepting than younger peers in integrating certain robotic technologies into daily life (Libin & Libin, 2008). Therefore, understanding older adults' perceptions and how they compare to that of other age groups could help us understand whether different approaches are needed for certain groups when using robotics. Nurse scientists developing robot-based interventions and practitioners using robots in care benefit from understanding attitudes towards robots. This, in turn, can help better identify where, how, and by whom robots could be accepted. Unfortunately, we currently have a limited understanding of attitudes across age groups of adults; most research only includes older adults (Beer et al., 2012; Broekens et al., 2009; Stafford et al., 2010; Stafford, MacDonald, Jayawardena, Wegner, & Broadbent, 2014) or only young and older adults (Libin & Libin, 2008). The purpose of this study was to explore the social impact of, comfort with, and negative attitudes towards robots among young, middle-aged, and older adults in the United States.

Methods

Design, Setting, and Sample

This study was a cross-sectional, descriptive study completed in a metropolitan area in the western United States. Individuals were recruited between April 2014 and January 2015 from the general population. Inclusion criteria were that participants could speak English and were ≥18 years old. No compensation was given for participation. The authors' Institutional Review Board (IRB) approved this study. Additional details about this study are available in [Hall and colleagues (2017)].

Measures and Procedures

Measures.—We deployed a survey that is described further in [Hall and colleagues (2017)]. The introduction defined robots as "an autonomous machine which can assist humans (e.g. as a coworker helping on the factory floor, cleaner, search and rescue in disasters), comes in various shapes or sizes, and can be human-like" (European Union [EU], 2015, p. 14). The survey included two questions taken or modified from an EU (2015) autonomous systems report and research by Broadbent and colleagues (Broadbent, Stafford, & MacDonald, 2009; Broadbent, Tamagawa, et al., 2009) with permission. One question had six items on social impacts of robots (1–5 point scale; 1 = *strongly agree* to 5 = *strongly disagree*). The other question had five items about comfort with situations involving robots (1–5 point scale; 1 = *totally comfortable* to 5 = *totally uncomfortable*). EU questions were within a widely used commissioned survey that did not include validity or reliability information. Items are listed in Table 2.

The survey also included one question that incorporated the Negative Attitudes Toward Robots Scale (NARS). It assesses attitudes towards interactions with robots and includes 14 items (Nomura, Kanda, & Suzuki, 2006; Syrdal, Dautenhahn, Koay, Walters, 2009; Tsui, Desai, Yanco, Cramer, & Kemper, 2010). Each item included a 1–5 point scale for which 1 = *strongly agree* to 5 = *strongly disagree*. The 14 items are divided into three subscales that capture negative attitudes towards situations and interactions with robots (Subscale 1, six items); social influence of robots (Subscale 2, five items); and emotions when interacting with robots (Subscale 3, three items). Item order in our survey was not grouped by scale. For consistency in scales across the survey, the original NAR scales were reversed so sentiment increased in negativity from 1 to 5. The NARS was the only scale that we could identify that assessed attitudes towards robots and has been found to have internal consistency, content and factorial validity, and test-retest reliability (Nomura et al., 2006; Syrdal et al., 2009).

Finally, the survey included one open-ended question for additional comments or clarifications. Respondents self-identified their age, gender, race, ethnicity, education, health, and current use of and confidence using robots and technologies that included checklist responses. See [Hall and colleagues (2017)] for descriptions of the questions. The final survey was reviewed by two groups of experts for face validity, clarity, and understandability.

Procedures.—To recruit individuals to complete the survey, we utilized convenience sampling. Research team members recruited individuals passing by while they stood in public spaces with high foot traffic and frequented by individuals of various cultural and socioeconomic backgrounds (e.g., public squares, community events, and markets). Team members also went to older adult community centers that were geographically accessible. Given the possibility of encountering more middle-aged adults in public spaces, we purposively sought locations where there were older and younger individuals so we could recruit adequate numbers of individuals from all age groups. When researchers encountered individuals, they described the study to interested individuals and assessed them for eligibility. If eligible and agreeable to participate, researchers gave the individual a paper survey and pencil in order to not bias responses based on an individual's technology access or use. Surveys were completed on site and returned to the researcher. In older adult community centers researchers also left surveys at the front desk for interested individuals to complete on their own and return to the front desk. Return of surveys indicated consent to participate as per procedures approved by the IRB.

Data entry and cleaning.—Three researchers entered survey data into a password-protected tool (RedCap). Responses were averaged when there were multiple responses for questions requiring one response. Double data entry was conducted for 25% (n = 125) of the surveys to identify instances when entered data differed due to incorrect data entry or differences in interpreting handwritten survey responses. Researchers discussed and came to consensus on final entries. Remaining surveys were completed with single entry. To ensure 100% accuracy of entered data, researchers (AKH and two undergraduate students) verified all entries by using a spreadsheet of all survey data downloaded from RedCap and comparing the spreadsheet data with paper surveys.

Analyses

We segmented respondents into age groups based on the U.S. Census Bureau groupings: age 18–44 years (young adult), 45–64 years (middle aged), and ≥65 years (older adult) (Howden & Meyer, 2011). The U.S. Census Bureau was selected to establish the age cutoffs because it is considered the "leading source of quality data about the nation's people" within the US, where the study was conducted (census.gov/about.html). We completed analyses to assess whether NARS mean summary scores were associated with demographics or non-NARS items that differed significantly by age group. Means and standard deviations or numbers and percentages were calculated when comparing respondents' demographic characteristics by age groups using one-way univariate analysis of variance (ANOVA) for normally distributed continuous variables, the Kruskal-Wallis test for ordinal variables and non-normally distributed continuous variables, chi-squared tests for categorical variables when cell values were ≥5, and Fisher's exact test for categorical variables when cell values were <5.

NARS scoring.—Scores for Subscales 1 and 2 were reversed to reflect the original scale definitions (1 = *strongly disagree* to 5 = *strongly agree*). An overall mean NARS summary score was then computed by taking the mean of the 14 items. Overall mean NARS score and subscale scores are therefore interpreted as follows: 1–2 indicates more positive attitudes towards robots; 3 indicates neutral attitudes towards robots; and 4–5 indicates greater negative attitudes towards robots (range = 1–5). We analyzed associations between demographic characteristics and NARS score using one-way univariate ANOVA for categorical characteristics and linear regression for numeric characteristics. We conducted post-hoc assessments using Tukey's honestly significant difference (HSD) test to assess pairwise comparisons between age groups when one-way ANOVA assessments were significant. We conducted a confirmatory factor analysis of the NARS using the lavaan package (Rosseel, 2012) and calculated a Cronbach's alpha for the NARS. We set significance at $P < .05$ and conducted analyses using R software (version 3.3.3, R Core Team, 2017).

Analysis of open-ended item.—A researcher (LK) performed a preliminary review of the responses to the open-ended question to identify those that were not related to the study question (e.g., "questionnaire is too long," "don't have anything in mind") or illegible. These flagged responses were not included in the analysis. The researcher assigned a theme to each major point discussed in a comment and, if applicable, a perception using thematic analysis (Boyatzis, 1998). Examples of themes include popular culture reference and societal concern. Perceptions were coded as positive, negative, or neutral. After the researcher assigned each comment to a theme and perception, they compared the number of comments associated with each theme and assessed for relationships between the themes and perceptions.

Results

Description of Survey Respondents and Technology Use

Table 1 provides summary data about respondent characteristics; detailed demographic and technology use information including a table of characteristics is available in [Hall and colleagues (2017)]. We had 499 completed surveys, and 474 respondents indicated their age: $n = 322$ age 18–44 years, $n = 50$ age 45–64 years, and $n = 102$ age 65–98 years. There were 239 men (49.7%) and 242 women (50.3%). Most were non-Hispanic (94.4%, $n = 440$) or White (64.5%, $n = 294$). Over a third (37.8%, $n = 184$) had some college and 49.4% ($n = 240$) had a bachelor's or graduate or professional degree. The mean health status was 2.2

(*SD* 1.0; 2.0 = "very good"). Most respondents (70.4%, *n* = 338) reported they did not have a chronic condition. Variables that differed significantly between age groups included demographic gender, race, ethnicity, education, number of chronic conditions, and perceived health status ($P < .05$). Many had no knowledge of robots (*n* = 161, 33.7%). Most respondents did not use a robot (*n* = 371, 74.4%). If respondents did use a robot, they mostly used them only at home (*n* = 71, 14.2%).

Table 1.

Abbreviated Demographic, Health, Robot, and Technology-Related Characteristics for Survey Respondents

	All respondents (*N* = 499)	18–44 years old (*n* = 322)	45–64 years old (*n* = 50)	65–98 years old (*n* = 102)
Age, mean years (*SD*)	38.7 (22.7)	24.3 (6.7)	55.4 (6.4)	76.0 (7.4)
Female gender, *n* (%)	242 (50.3)	**141 (42.8)**	**26 (52.0)**	**71 (70.3)**
Bachelor's or graduate/professional degree, *n* (%)	240 (49.4)	**143 (44.5)**	**33 (67.4)**	**57 (55.9)**
No chronic conditions, *n* (%)	338 (70.4)	**273 (85.6)**	**32 (68.1)**	**25 (25.0)**
Perceived health status,[a] mean (*SD*)	2.2 (1.0)	2.1 (1.0)	2.2 (1.1)	2.6 (1.0)
Do not use robot, *n* (%)	371 (74.4)	228 (70.8)	42 (84.0)	86 (84.3)
No robot knowledge, *n* (%)	161 (33.7)	104 (33.0)	15 (30.6)	38 (38.0)
Daily internet access, *n* (%)	419 (87.8)	**304 (96.5)**	**43 (87.8)**	**61 (61.6)**
Confidence in two or more technologies,[b] *n* (%)	434 (87.0)	**309 (96.0)**	**43 (86.0)**	**72 (70.6)**
Two or more technologies in the home, *n* (%)	441 (88.4)	**314 (97.6)**	**42 (84.0)**	**79 (77.5)**

For full details of these characteristics see Hall and colleagues (2017). Boldface values indicate $P < .05$. Significant differences between age groups was assessed via one-way univariate analysis of variance tests for continuous normally distributed variables; Kruskal-Wallis tests for ordinal variables and non-normally distributed continuous variables; chi-squared tests for categorical variables with cell values of ≥5; and Fisher's exact tests for categorical variables with cell values of <5.

[a]Perceived health score ranged from 1 (*excellent*) to 5 (*poor*).

[b]Technologies included tablet computer, laptop or desktop computer, smart TV with Internet apps, video call (e.g., Skype), email, and social media (e.g., Facebook).

Internet use was greater among young adults (YAs) than middle-aged adults (MAs) and older adults (OAs; YAs *n* = 304, 96.5%; MAs *n* = 43, 87.7%; OAs *n* = 61, 61.6%; $P < .05$). YAs reported confidence in two or more technologies at greater rates than MAs and OAs (YAs *n* = 309, 96.0%; MAs *n* = 43, 86.0%; OAs *n* = 61, 70.6%; $P < .05$). More YAs reported having two or more technologies in the home than did MAs or OAs (YAs *n* = 314, 97.6%; MAs *n* = 42, 84.0%; OAs *n* = 79, 77.5%; $P < .05$).

Perceptions of Robots and Comfort With Robots Completing Tasks

Responses were similar for 10 of the 11 items regarding social impact of and comfort with robots (see Table 2). Respondents generally agreed that robots are good for society because they are helpful (mean 2.1 [*SD* 1.0]) and necessary because they do jobs too hard or dangerous for people (mean 1.8 [*SD* 0.9]). There was agreement that robots require careful management (mean 1.7 [*SD* 0.9]). Respondents were neutral about robots boosting job opportunities (mean 2.7 [*SD* 1.4]), stealing jobs (mean 2.9 [*SD* 1.2]), or performing an operation on them (mean 3.2 [*SD* 1.3]). They were more uncomfortable with robots walking dogs (mean 3.5 [*SD* 1.3]) or caring for elderly parents or children (means [*SD*s]: 3.8 [1.2] and 4.2 [1.0], respectively).

Only 1 of the 11 items regarding social impact of robots and comfort with robots resulted in significant differences between age groups (see Table 2). Post hoc tests indicated that younger adults were more comfortable than older adults having a robot to assist at work ($P < .05$). Means [*SDs*] were 1.8 [1.0] and 2.1 [1.1], respectively; both means are close to 2.0, which indicates "somewhat comfortable" on the original scale.

Negative Attitudes Towards Robots

Individual NARS items.—There were no significant differences between age groups for 6 of 11 NARS items (Table 3). For the items indicating feeling uneasy if robots had emotions or that something bad might happen if robots developed into living beings, the mean scores for each age group were around 2.0 (indicating "agree" on the original scale). Each of the age groups had mean scores of around 3.0 (indicating "neutral" on the original scale) for the items regarding feeling relaxed talking with robots, paranoid talking with a robot, concerned that robots would be a bad influence on children, and that robots will dominate society in the future. The mean scores for each of the age groups was around 4.0 (indicating "disagree" in the original scale) for the following items: that the word "robot" means nothing to them and they would feel comforted being with robots with emotions, nervous operating a robot in front of others, or nervous just standing in front of a robot.

Five of the 11 NARS items significantly differed by age group (see Table 3). For post hoc pairwise comparisons between YAs and either MAs or OAs, YAs were less negative regarding being friends with robots with emotions (means [*SDs*]: YAs = 3.1 [1.1], MAs = 3.7 [1.0], OAs = 3.6 [1.2]) or feeling comforted being with robots with emotions (means [*SDs*]: YAs = 3.5 [1.0], MAs = 3.8 [1.0], OAs = 3.8 [1.1]). YAs were more positive than MAs and OAs regarding feeling something bad might happen if they depended too much on robots (means [*SDs*]: YAs = 2.6 [1.2], MAs = 3.1 [1.0], OAs = 3.2 [1.2]). MAs and OAs agreed more than YAs regarding feeling anxious if given a job or task using robots (means [*SDs*]: YAs = 3.6 [0.9], MAs = 3.3 [1.0], OAs = 3.3 [1.1]). In a post hoc pairwise comparison of YAs and OAs, OAs agreed more that they would hate the idea that robots or artificial intelligence agents were making judgments (means [*SDs*]: YAs = 2.8 [1.1], OAs = 2.5 [1.3]). Mean scores for all items for which there were significant differences between age groups were generally between 3.0 (indicating "neither agree or disagree" on the original scale) and 4.0 (indicating "disagree"). Confirmatory factor analysis of the NARS items suggested a less than perfect fit (root mean square error of approximation = 0.110, 90% confidence interval = 0.101–0.120). The NARS Cronbach's alpha was 0.84.

Overall NARS score and subscale scores.—There were no differences by group for the mean overall NARS score and Subscale 1 scores. The mean overall NARS score was 3.0 for all age groups, indicating "neither agree or disagree" or having a neutral attitude. Mean scores for Subscale 1 were between 2.0 (indicating a more positive attitude) and 3.0 (indicating a neutral attitude).

There were significant differences by age groups in mean scores for Subscales 2 and 3. In a post hoc pairwise comparison between YAs and either MAs or OAs, YAs had higher mean scores for Subscale 2 (means [*SDs*]: YAs = 3.3 [0.8], MAs = 3.1 [0.7], OAs = 3.1 [0.8]), $P < .05$); these means are close to 3.0 in the original scale, indicating “neither agree or disagree” or having neutral attitudes towards robots. YAs had lower mean scores for Subscale 3 than did MAs ($P < .05$). For YAs the mean score for Subscale 3 was 3.2 [*SD* 0.9], near 3.0, indicating “neither agree or disagree” on the original scale or having neutral attitudes towards robots. In comparison, the mean Subscale 3 score for MAs was 3.6 [*SD* 0.9], which was closer to 4.0, indicating “disagree” or a more negative attitude toward robots.

The mean overall NARS score was inversely associated with frequency of web access and confidence in using technologies ($P < .05$). Gender was associated with overall mean NARS score (3.1 for females and 2.9 for males, $P < .05$). There were no associations between mean overall NARS score and perceived health, race, ethnicity, education, and number of technologies in the home (data not shown).

Open-Ended Responses

Of the 499 surveys completed, 109 included comments. Of these, 27 did not relate to the study question or were illegible and were excluded in analyses, yielding 82 comments eligible for analysis. Among the 82 eligible, 78 reported their age. Forty-two (53.9%) were 18–44 years old, 14 (17.9%) were 45–64 years old, and 22 (28.2%) were ≥65 years old.

Respondents discussed popular culture influencing their viewpoint on robots. Positive comments referenced exposure to robots in media. One respondent said, “I really like Star Trek: TNG [the Next Generation] so my idea of a robot was really influenced by the idea of an android like Data [a robot on the show].” Respondents were affected by negative media portrayals of robots. Seven respondents (8.5%) brought up Hal 3000, a robot that attempts to kill humans in the movie “2001: A Space Odyssey,” and Karel Capek books such as iRobot, or made references to the “Terminator” movies. One respondent stated, “Robots can get smart and kill people. Haven’t you guys seen ‘The Terminator’?” Another stated, “noted scholar Stephen Hawking, who is known and renowned for his superior intelligence, … warns against the use….”

Respondents who wrote positive comments discussed prior exposure to robotics by volunteering or participating in student robotics clubs. Five respondents (6.1%) mentioned experiences with a university-affiliated volunteer organization, which provides robotic-themed after school activities to primary and secondary school students, as the reason for their positive impressions of robots. As one respondent stated, “I participated in the world FIRST competition last year and it opened my eyes more to the greatness of robotics.”

Some respondents who had negative attitudes towards robots noted concerns that robots would replace humans in the workforce or decrease human interaction. Respondents saw both scenarios as significant issues with mainstreaming robotic technology. As one respondent stated, “Being from India we have a lot of people in our country and they need livelihood, so more of robots in the world would mean less jobs and poverty, unhappiness, violence, hatred.” Another respondent stated, “There are things robots can do that would be helpful, medically. I believe they will take away jobs, not create.” One respondent stated, “Robots ok for technical stuff in home such as turning lights on or off but nope, not storytelling, walk dog, etc. Human interaction very important.” Another stated, “I believe robots used to perform tasks hazardous to humans are necessary. [I] do not want robots to replace or minimize human interaction.”

Discussion

Nursing scientists and practitioners are at the front line of care and pioneers in engaging with new methods to support individuals’ health. With the development and integration of robotic solutions in various health and wellness domains and settings, nurse scientists and practitioners are integral to efforts that support efficacious introduction of robotic technologies into patients’ lives. This study strives to support this work by providing insights into individuals’ perceptions of robots; these perceptions are important for us to understand to ensure appropriate and proper integration of robotic technologies into people’s lives and care. In our survey assessing adults’ attitudes towards robots, we found few differences among younger, middle-aged, and older adults’ perceptions of the social impact of robots, their comfort with robots in various situations, and negative attitudes towards robots. Items for which there were statistically significant differences in mean scores by age group were not practically significant; mean scores indicated similar sentiments on the original 5-point scales. This study suggests that nurse scientists and practitioners are likely to encounter similar attitudes towards robots among adults of all ages for whom they develop or deploy robotic interventions.

Our findings are congruent with prior research that assessed attitudes towards robots. We found in our study that older adults along with young and middle-aged adults did not consistently report negative feelings toward robots; instead, respondents were generally supportive of or neutral towards robots. Also, respondents on average indicated that they thought robots were useful and disagreed that robots were dangerous. These findings align with prior research that only included older adults (Beer et al., 2012; Broekens et al., 2009) or compared only young and older adults (Libin & Libin, 2008). This suggests that older adults along with younger and middle-aged adults may be accepting of interventions including robotic solutions that are developed or deployed by nurse scientists and practitioners, as hypothesized in the Technology Acceptance Model (Venkatesh & Davis, 2000).

We assessed these differences in attitudes among adults of all ages through our study’s methods, which addressed sample limitations in prior research. We recruited adults of all ages so we could assess attitudes using validated measures among young, middle-aged, and older adults. This is in contrast with previous studies that assessed perceptions or attitudes towards robots only among a single age group, involved small samples, or were pre-post studies with a prototype robot interaction component (Prakash et al., 2013; Ray, Mondada,

& Siegwart, 2008; Reich-Stiebert & Eyssel, 2015; Shin & Kim, 2007; Stafford et al., 2010; Stafford et al., 2014). Therefore, we provide a new, more complete perspective across all adult ages.

Our study also adds to the global research regarding adults' attitudes towards robots. Most research has been completed outside the United States, including New Zealand (e.g., Stafford et al., 2014), Korea (Shin & Kim, 2007), and Europe (e.g., Ray et al., 2008). Several of these studies found that older adults were wary of robots. Among the few studies conducted in the United States, researchers found older and younger adults had similar perceptions regarding the impact of technologies (Libin & Libin, 2008; Smith, 2014; Smith & Anderson, 2014), which aligns with our study comparing young, middle-aged, and older adults. It is possible that the lack of consistency across findings from studies conducted in various parts of the world could be related to differences in cultural norms. This can include what is considered an acceptable mode of interaction between humans and robots as well as roles and tasks deemed acceptable for robots (Lee, Sung, Šabanović, & Han, 2012; Wang, Rau, Evers, Robinson, & Hinds, 2010). More research is needed to understand what and how cultural norms across the United States and the globe can impact attitudes towards robots. This is of particular pertinence for nurse scientists and practitioners developing or deploying culturally congruent and competent interventions that include robots engaging with individuals in health or ADL-related activities.

In addition, nurse scientists and practitioners using robotic interventions would benefit from considering adults' attitudes towards robots' roles and interactions. Our findings suggest that adults of all ages could be more accepting of robots that support nurses but not replace them. In our survey, respondents of all age groups were uncomfortable with the idea of robots caring for children or older adults. This discomfort was echoed within the open-ended responses; several respondents expressed fear about robots decreasing human interaction. While respondents expressed that robots would be useful in supporting humans in their work, they were wary about robots replacing humans in certain roles in which nurses are often engaged.

This study also dispels a perception that robotic technologies are accepted by younger adults whereas older adults must be convinced that robots could be useful. Contrary to this perception, we found that respondents, regardless of age, reacted similarly to most items about the psychosocial impact of robots. Even among the few items where there were significant differences in attitudes by age group, the mean scores for the groups being compared almost always reflected similar sentiments on the original 1–5 point scale in the survey. This is an important finding for nurse scholars and practitioners developing and implementing robots into practice. Our study suggests that older adults may be willing to use robots to help perform work duties, which may signal acceptance of using robots to support independent living, a domain in which nurses often work. This is congruent with previous studies, which found that older adults are willing to trade some autonomy in exchange for being able to continue to live independently (Demiris, 2009). Therefore, nurse scholars and researchers can use this study to inspire more robotic intervention work among older adults who had similar attitudes towards robots as other adults.

To support this robotic intervention work, nurse scholars and practitioners can use findings from this study to investigate how gender, web access, and confidence in using technologies can influence attitudes towards robots; this can also include investigating how the intersectionality of these other demographic factors may impact attitudes. For example, we found an association between overall NARS score, indicating that men had a more positive attitude towards robots than women did. A possible explanation that nurse scholars could investigate is that men may have more exposure to robots than women and starting early in life. Gender bias exists among educators in science, technology, engineering, and math (STEM fields), with educators providing less encouragement to female than male students (Lavy & Sand, 2015; Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012). This could impact women's exposure to, comfort with, and confidence using technologies including robots. Thus, nurse scholars should not view differences in NARS scores by gender as indicating inherent differences in technological abilities or attitudes. Rather, we should acknowledge the bias-related gap women faced throughout their education and develop strategies to address that gap when developing robotic interventions.

Our study has several limitations. Respondents were from an urban city that is home to many technology companies, which limits the generalizability of our findings to other cities or countries. Our sample had overrepresentation of individuals self-identifying as Asian and underrepresentation of individuals self-identifying as Black/African American as compared to the census for the geographic area where our study took place. We did not track the numbers of individuals who were recruited from each site or who were approached to participate but declined. Because the purpose of this study was to assess attitudes among the general population, we did not specifically recruit older adults who are immobile or frail; future research could specifically recruit these individuals. Our grouping of individuals by age was guided by U.S. Census groupings; there may be other age groupings relevant to our research aims (e.g., by generation). We used the definition of a robot provided in the EU (2015) report for consistency because questions from the EU survey were included in our survey; however, the definition is broad and survey respondents may have had differing conceptions of a robot based on their interpretations of the definition. Also, the confirmatory factor analysis of the NARS suggested less than perfect fit. This could indicate that items in the NARS could be measuring multiple factors rather than a single factor. The EU (2015) report from which we used questions for our survey did not provide information about reliability or validity of their survey; we also did not assess reliability of the full survey used in this study. However, the NARS has been assessed for validity and reliability and we were able to assess our full survey for face validity. For open-ended question responses, a single researcher analyzed the data; therefore, there was no interrater assessment of the coding scheme or coded text. Finally, we had unequal sample sizes across the age groups, which could have impacted our findings. Therefore, statistical comparisons between the middle-aged group (smallest sample size) and either young adult or older adult groups (larger sample sizes) have less statistical power than comparisons between the young and older adult groups (both larger sizes).

Given nursing's key role supporting the health of adults, nursing has the potential to revolutionize the development and implementation of robotic technologies. Nurses have insights on novel ways robotics can be developed and used, exemplified in the MakerNurse community (makernurse.com). Nurses can advocate for patients' involvement in developing robots (e.g., through engaging in user-centered design) and evaluation (e.g., through user experience evaluations). Nurses can advocate for the needs and preferences of patients as part of design and implementation teams for these technologies. Furthermore, they can highlight ethical and practical considerations ensuring that new technologies do not negatively impact the clinician–patient relationship and do not lead to more isolation for their patients.

Conclusions

In our survey, we found that younger, middle-aged, and older adults responded similarly regarding the social impact of, comfort with, and negative attitudes towards robots. While there were some differences in attitudes among age groups regarding comfort with and negative attitudes towards robots, almost all perceptions across age groups reflected similar attitudes. Findings dispel perceptions that older adults are not as welcoming to robots as younger adults. This research has implications for nurses who design, develop, and use robotic interventions that play supportive roles in society.

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- User-centered design basics. https://www.usability.gov/what-and-why/user-centered-design.html

Table 2.

Mean (*SD*) of Attitudes About the Social Impact of Robots[a] and Comfort With[b] Robots Completing Certain Tasks Among All Respondents and by Age Group

	All (N = 499)	18–44 years old (n = 322)	45–64 years old (n = 50)	65–98 years old (n = 102)
Agreement regarding social impact of robots				
Robots are a good thing for society, because they help people.	2.1 (1.0)	2.1 (0.8)	2.0 (0.8)	2.1 (1.0)
Robots steal peoples' jobs.	2.9 (1.2)	2.9 (1.1)	2.8 (1.0)	2.9 (1.1)
Robots are necessary as they can do jobs that are too hard or too dangerous for people.	1.8 (0.9)	1.8 (0.8)	1.7 (0.7)	1.7 (0.9)
Robots are a form of technology that requires careful management.	1.7 (0.9)	1.7 (0.7)	1.7 (0.8)	1.6 (0.8)
Widespread use of robots can boost job opportunities in the United States.	2.7 (1.4)	2.7 (1.1)	2.8 (1.0)	2.9 (1.0)
Robots are dangerous for humanity.	3.6 (1.1)	3.5 (1.0)	3.8 (0.9)	3.7 (1.0)
Comfort in the following situations				
Having a robot assist you at work	1.9 (1.0)	1.8 (1.0)[c]	1.9 (1.0)	2.1 (1.1)[c]
Having your dog walked by a robot	3.4 (1.3)	3.4 (1.3)	3.7 (1.1)	3.2 (1.3)
Having a medical operation performed on you by a robot	3.2 (1.3)	3.2 (1.3)	3.4 (1.3)	3.4 (1.3)
Having your children cared for by a robot	4.2 (1.0)	4.1 (1.0)	4.4 (0.9)	4.2 (1.0)
Having your elderly parents cared for by a robot	3.8 (1.2)	3.8 (1.2)	4.0 (1.2)	3.9 (1.2)

[a]Range 1–5; 1 = *strongly agree* to 5 = *strongly disagree*.

[b]Range 1–5; 1 = *totally comfortable* to 5 = *totally uncomfortable*.

[c]Statistically significant pairwise differences between younger and older adults via post hoc testing ($P < .05$).

Table 3.

Mean (*SD*) of Responses to Items From the Negative Attitudes Toward Robots Scale Among All Respondents and Across Age Groups[a,b]

	All	18–44 years old (*n* = 322)	45–64 years old (*n* = 50)	≥65 years old (*n* = 102)
Agreement regarding				
I would feel uneasy if robots really had emotions.[c]	2.2 (1.1)	2.2 (1.0)	2.2 (1.1)	2.1 (1.1)
Something bad might happen if robots developed into living beings.[c]	2.3 (1.1)	2.3 (1.0)	2.3 (1.1)	2.2 (1.2)
I would feel relaxed talking with robots.[d]	3.0 (1.1)	3.0 (1.0)	3.2 (1.1)	2.9 (1.2)
I would feel anxious if I was given a job or task where I had to use robots.[e]	3.5 (1.0)	3.6 (0.9)[f,g]	3.3 (1.0)[f]	3.3 (1.1)[g]
If robots had emotions I would be able to make friends with them.[d]	3.3 (1.1)	3.1 (1.1)[f,g]	3.7 (1.0)[f]	3.6 (1.2)[g]
I feel comforted being with robots that have emotions.[d]	3.6 (1.1)	3.5 (1.0)	3.8 (1.0)	3.8 (1.1)
The word “robot” means nothing to me.[e]	3.8 (1.0)	3.8 (0.9)	4.0 (0.8)	3.6 (1.1)
I would feel nervous operating a robot in front of other people.[e]	3.5 (1.0)	3.6 (1.0)	3.6 (0.9)	3.5 (1.1)
I would hate the idea that robots or artificial intelligences were making judgments about things.[e]	2.7 (1.2)	2.8 (1.1)[g]	2.5 (1.2)	2.5 (1.3)[g]
I would feel very nervous just standing in front of a robot.[e]	3.7 (1.1)	3.8 (1.1)	3.8 (0.8)	3.7 (1.1)
I feel that if I depend on robots too much, something bad might happen.[c]	2.7 (1.2)	2.6 (1.2)[f,g]	3.1 (1.0)[f]	3.2 (1.2)[g]
I would feel paranoid talking with a robot.[e]	3.3 (1.1)	3.3 (1.1)	3.4 (1.0)	3.5 (1.1)
I am concerned that robots would be a bad influence on children.[c]	3.3 (1.1)	3.3 (1.1)	3.2 (1.1)	3.4 (1.1)
I feel that in the future society will be dominated by robots.[c]	3.2 (1.2)	3.1 (1.1)	3.4 (1.0)	3.4 (1.3)
Summary scores				
Overall[h]	3.0 (0.6)	3.0 (0.6)	3.0 (0.5)	3.0 (0.7)
Subscale 1[e]	2.6 (0.7)	2.5 (0.7)	2.6 (0.6)	2.7 (0.9)
Subscale 2[c]	3.3 (0.8)	3.3 (0.8)	3.1 (0.7)	3.1 (0.8)
Subscale 3[d]	3.3 (0.9)	3.2 (0.9)[f]	3.6 (0.9)[f]	3.4 (1.0)

[a] Comparing respondents by age groups using one-way univariate analysis of variance.

[b] Range 1–5; 1 = *strongly agree* to 5 = *strongly disagree*.

[c] Items included in Subscale 2. Missing data points for Subscale 2: 4 for age 18–44 years, 2 for age 45–64, 14 for age ≥65 years.

[d] Items included in Subscale 3. Missing data points for Subscale 3: 4 for age 18–44 years, 2 for age 45–64, 15 for age ≥65 years.

[e] Items included in Subscale 1. Missing data points for Subscale 1: 4 for age 18–44 years, 5 for age 45–64, 11 for age ≥65 years.

[f] Statistically significant pairwise differences between younger and middle-aged adults via post hoc testing ($P < .05$).

[g] Statistically significant pairwise differences between younger and older adults via post hoc testing ($P < .05$).

[h] Increased negative attitudes with increased value. Summary score is the mean of the total for the 14 items. Reversed scales were used for items from Subscales 1 and 2 and the original scale from Subscale 3. Missing data points: 11 for age 18–44 years, 4 for age 45–64, 28 for age ≥65 years.

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