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Exploring Surgeons', Nurses', and Patients' Information Seeking Behavior on Medical Innovations

The Case of 3D Printed Biodegradable Implants in Breast Reconstruction

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Objectives: To explore information seeking behavior on medical innovations.

Background: While autologous and alloplastic options for breast reconstruction are well established, it is the advent of the combination of 3D printing technology and the biocompatible nature of a highly porous biodegradable implants that offers new treatment options for the future. While this type of prosthesis is not yet clinically available understanding how patients, surgeons, and nurses take up new medical innovations is of critical importance for efficient healthcare provision.

Materials and Methods: Using the largest ever combined sample of breast cancer patients (n = 689), specialist surgeons (n = 53), and breast care nurses (n = 101), we explore participants preference for a new surgical treatment concept rooted in 3D printed and biodegradable implant technologies in the context of breast reconstruction.

Results: We find that patients overwhelmingly favor information from a successful patient of the proposed new technology when considering transitioning. Surgeons and nurses instead favor regulatory body advice, peer-reviewed journals, and witnessing the procedure performed (either in person or online). But while 1 in 4 nurses nominated talking to a successful patient as an information source, not a single surgeon chose the same. Our multinomial logit analysis exploring patient preference (controlling for individual differences) showed statistically significant results for both the type of surgical treatment and choice to undergo reconstruction. Women who underwent a type of mastectomy procedure (compared with lumpectomy patients) were more likely to choose a former patient than a surgeon for seeking information relating to a new breast implant technology. Further, women who chose to undergo a reconstruction procedure, compared with those who did not, where more likely to prefer a surgeon for information relating to a new breast implant technology, rather than a successful patient. For medical professionals, we find no statistically significant relationship between medical professionals' preference and their age, nor the number of other medical professionals they work with daily, nor the average number of breast procedures performed in their practice on a weekly basis.

Conclusions: As our findings show large variation exists (both within our patient group and compared with medical professionals) in where individuals favor information on new medical innovations, future behavioral research is warranted.

Keywords: 3D printing, biomaterials, breast cancer, breast reconstruction, new medical technologies, preference

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Data and code are available on request of the corresponding author. All research was conducted in accordance with Queensland University of Technology Human research Ethics Committee approval number 1800000669.

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INTRODUCTION

While autologous and alloplastic options for breast reconstruction are well established, it is the advent of the combination of 3D printing technology and the biocompatible nature of a highly porous biodegradable implant that offers new treatment options for the future. Currently, this type of prosthesis is not clinically available. However, understanding where breast cancer patients, surgeons, and breast care nurses look for information on future technologies such as these is pivotal for the development of a potential prosthesis that will both fill clinical need and meet the needs and expectations of patients and clinicians alike.

The scientific exploration of regenerative medicine and particularly biomaterials has grown exponentially this millennia.[1–7] It is estimated that globally more than a million patients have already been treated with some form of regenerative medicine.[8] While the benefits of using one's own biology to support the healing of trauma or medical conditions is obvious, exactly how healthcare professionals and patients cognitively shift their preference to new medical innovations, which have the potential to lead to a paradigm shift in surgical treatment concepts is unclear.

The adoption of new medical innovations can be influenced by a range of individual, organizational, environmental, financial, personal, legal, biological, systemic, and innovation-related characteristics.[9,10] Research has shown that an individual's general attitude towards a particular new technology can be directly related to one's own belief in scientific progresses ability to solve an emerging problem,[11,12] their limited knowledge of the (biomedical) technology itself,[13] and the level of trust they have or perceive in it.[14] The general public's attitudes toward medical innovations are also significantly determined by the perceived risks and benefits of using such. Independent of any specific medical condition, said risks and benefits can be driven by a range of factors, such as one's general attitudes towards new technology, social trust, perceived public trust, and knowledge.[14]

The inspiration for using tissue engineering & regenerative medicine for breast reconstruction provides an innovative substitute for silicone implants. Ongoing preclinical research applying biomaterials with a well-established clinical track record, such as medical-grade polycaprolactone Mn, will allow for fast translation of these new type of implants to a clinical setting. 3D printed medical-grade polycaprolactone scaffolds for breast reconstruction aim to guide the regeneration by providing a physical template of the patient's own via liposuction harvested body fat. The nature of 3D printing offers the ability to manufacture patient-specific implants of clinically relevant volumes and sizes. However, while being on the cusp of clinical translation, more information is needed on receptiveness of the clinical and public domain to uptake of such technologies.

To date, there exists no research exploring how surgeons, nurses, and patients choose to transition to emerging medical implant innovations, such as 3D printed technologies. It is even unclear exactly where these parties would seek information from before considering transition. As such our study identifies and compares surgeons (n = 53), nurses (n = 101), and patients' (n = 689) preferred conduits for information relating to new 3D printed biocompatible prothesis in breast reconstruction. The study also explores the relationship between key individual differences in patient sociodemographics, type of breast cancer treatment, and type of reconstruction procedure on patient's preference.

METHODS

Data Capture

These data were collected using the Queensland University of Technology (QUT) KeySurvey online survey software. Our online survey consisted of a range of demographic questions such as age, height and weight (body mass index [BMI]), education level, private health insurance, and annual income (See Table 1). Breast cancer patients also provided information relating to the type of breast cancer treatment they underwent (lumpectomy, mastectomy, bilateral mastectomy, or prophylactic mastectomy) and they are choice regarding a reconstruction (no reconstruction, implant based, tissue based, or combination of implant/tissue), see Table 2.

Participants provided informed consent upon completion of the survey, and all research was conducted in accordance with the approved QUT Human Research Ethics Committee protocol (approval number 1800000669). As part of the participant information provided prior to participation, individuals were explained that the context of the survey centered on the development and use of new biomaterials technologies in breast reconstruction.

To promote the study, the researchers engaged the following related breast cancer charities and organizations who assisted in advertising the study to their respective memberships. Those being the Australasian Society of Aesthetic Plastic Surgery, the Australian Society of Plastic Surgeons, Breast Cancer Network Australia, Breast Wishes Journey, Cancer Nurses Society Australia, Dragon Abreast Australia, and the McGrath Foundation. All data was captured between December 2018 and October 2019. Some data used in this research were used in previous unrelated studies.[15,16]

As part of the QUT University Human Research Ethics Committee participant disclosure process, all participants were provided with specific information relating to advances in new biomaterials breast technology. However, because of the

TABLE 1.

Patient Descriptive Statistics: Treatment, Diagnosis, Reconstruction, Education, and Private Insurance

Patient Variable	N (%)
Type of reconstruction:	
Implant-based approach	139 (30.62)
Tissue-based approach	121 (26.65)
Combination tissue and implant approach	36 (7.93)
Decided not to have a reconstruction	158 (34.80)
Total	N = 454
Type of breast cancer treatment:	
Lumpectomy	169 (27.57)
Mastectomy	137 (22.35)
Bilateral mastectomy	291 (47.47)
Prophylactic mastectomy	16 (2.61)
Total	N = 613
Diagnosis:	
ILC	89 (14.29)
IDC	232 (37.24)
DCIS	159 (25.52)
LCIS	17 (2.73)
BRCA 1,2	28 (4.49)
Others	14 (2.25)
No information provided	84 (13.48)
Total	N = 623
Education level:	
Below grade 10	4 (0.61)
Grade 10 or 11	83 (12.71)
Grade 12	62 (9.49)
Technical/pre-vocational	84 (12.86)
Undergraduate	217 (33.23)
Postgraduate	183 (28.02)
Doctor/PhD	20 (3.06)
Total	N = 653
Private health insurance	400 (64.52)
Total	N = 620

Due to the QUT UHREC clearance, participants were not required to fill out any question they did not wish to answer. Hence, sum totals for each variable do not match.

BRCA indicates breast cancer gene; DCIS, ductal carcinoma in situ; IDC, invasive ductal carcinoma; ILC, invasive lobular carcinoma; LCIS, lobular carcinoma in situ; UHREC, University Human Research Ethics Committee.

TABLE 2.

Patient Descriptive Statistics: Age, BMI, and Income

Variable	N	Mean	SD	Minimum	Maximum
Age	689	56.87	11.1468	20	82
BMI	671	27.51	6.06597	14.51	55.26
Income (AUD)	536	$60,681.41	$44,988.63	$10,000	$200,000

significant variance in technical knowledge between the 3 groups, the word "bio-materials" was not explicitly used in the study. Rather the research team provided participants an extensive lay explanation of a 3D printed breast scaffold, its benefits, and the motivation for the study, as outlined below,

> The printed implant will serve as the building block for the patient's own breast tissue to grow. The scaffold will then dissolve leaving the new breast tissue. A benefit of this technique is that patients will have the opportunity to have a breast reconstruction using their own tissue, rather than replacing their breasts using other options (such as a silicone implant). Importantly, it is a less invasive and easier reconstructive technique, meaning more patients will have access to this surgery with less negative complications.

Participants were then given a single option categorical question asking their preference for information when considering a shift to a new medical technology in the context of breast reconstruction.

If there was a new reconstructive breast technology introduced in clinical practice, are you most likely to consider using this new technology after:

- reading about it in a peer-reviewed medical journal
- seeing that the procedure is now endorsed or recommended by the relevant surgical society or authority
- talking to a surgeon that they have successfully performed the procedure
- talking to a breast care nurse who has worked with patients who have undergone the treatment
- talking to former patients who have undergone the new treatment about their experiences.
- witnessing the procedure performed in person
- witnessing the procedure performed online or via-video link

Participants were only permitted to choose their most favored option. As it was evident that witnessing the procedure in person was a highly implausible option for breast cancer patients, the choice option was removed for those participants. For convenience of analysis, the 7 categories were then condensed to the following abbreviated titles.

1. A peer-reviewed journal
2. Surgical society or regulator endorsement
3. Surgeon of successful patient
4. Nurse of successful patient
5. Successful patient
6. Witnessing procedure (in person)—Surgeon & Nurse only
7. Witnessing procedure (not in person)

Descriptive Statistics

In Table 1, we present patient descriptive statistics: treatment, diagnosis, reconstruction, education, and private insurance. In Table 2, Patient descriptive statistics: age, BMI, and income.

Analysis

In Figure 1, we present a graphical representation of participant preference for information regarding transitioning to a new breast reconstruction technology. Each of the 7 categories are further visually grouped by color, with shades of red (peer-reviewed journal; surgical society or regulator endorsed), shades of blue (Surgeon of successful patient; Nurse of successful patient; Successful patient), and shades of green (Witness the procedure [in person]; [not in person]).

To analyze any potential relationship between individual patient differences and their choice of information conduit, we conduct multinomial logistic regression (see Table 3 for model specifications).

In Table 4 (n = 428)[1] (see Table 5—for responses restricted to nonmissing observations), we model the nominal outcome variables (ie, preference for information from), presenting the log odds ratios (ORs) of the outcomes modeled as a linear combination of the patient's individual differences.

These primary patient factors include women's type of breast cancer treatment (lumpectomy, mastectomy, bilateral mastectomy, or prophylactic mastectomy) and women's choice regarding reconstruction (no reconstruction, implant based, tissue based, or combination of implant/tissue).

In Table 6 (n = 368), we expand this model to control for patient age, BMI, education level, private health insurance, and annual income. Importantly, we also explore the impact of both patient cancer diagnosis, and any type of postsurgery treatment. The coefficients are interpreted as log ORs relative to the baseline group in each category, relative to the choice of the base outcome (speaking to a successful patient). Finally, as only 7 of n = 587 women chose the option "Witness procedure" (1.19%), for simplicity we exclude these observations from our multivariate modeling.

In Table 7, we explore medical professional preferred point of reference on adopting new breast reconstruction biomaterials. Our multinominal logit model utilizes the baseline comparison group of "successful patient," with control variables of surgeons age, the practice setting of the surgeon (public vs private, combination of both), number of other specialist peers in their current practice, and average number of breast procedures performed in their practice per week.

RESULTS

In Figure 1, we find more than two thirds of breast cancer patients (combined 67.8%) selecting an option that involves information directly or indirectly from a successful patient of the new technology. For our combined medical professional's group, 58.6% of the n = 128 sample state a preference for information from an evidence-based source such as peer-reviewed journal or surgical society or regulatory body. Interestingly, not a single breast surgeon selected the "Nurse of successful patient" or "Successful patient" option. Rather their preference is dominated by the regulatory endorsement option and witnessing the procedure options. Finally, nurses exhibit far less variance in preference with only 4 out of 7 options selected. Nurses relative to surgeons, chose more of the regulatory endorsement option, and Nurses, relative to patients, chose the successful patient option comparably (Patient = 25.55%; Nurse = 24.00%).

Our multinomial logit regression analysis in Table 4 shows statistically significant OR results for all categorical comparisons of patients selecting "Surgeon of successful patient," compared with the base outcome group of "Successful patient." When comparing women who underwent a procedure that involved mastectomy (mastectomy, OR = 0.253, $P < 0.01$; Bilateral, OR = 0.188, $P < 0.01$; and Prophylactic, OR = 0.068, $P < 0.05$) to women who underwent a lumpectomy procedure, we see that mastectomy patients are less likely to choose the surgeon as their most influential option for transition to a new

[1] *Due to University Human Research Ethics Committee requirements participants were not required to complete every question, as such sample size is reduced to the maximum number of participants completing every question of interest.*

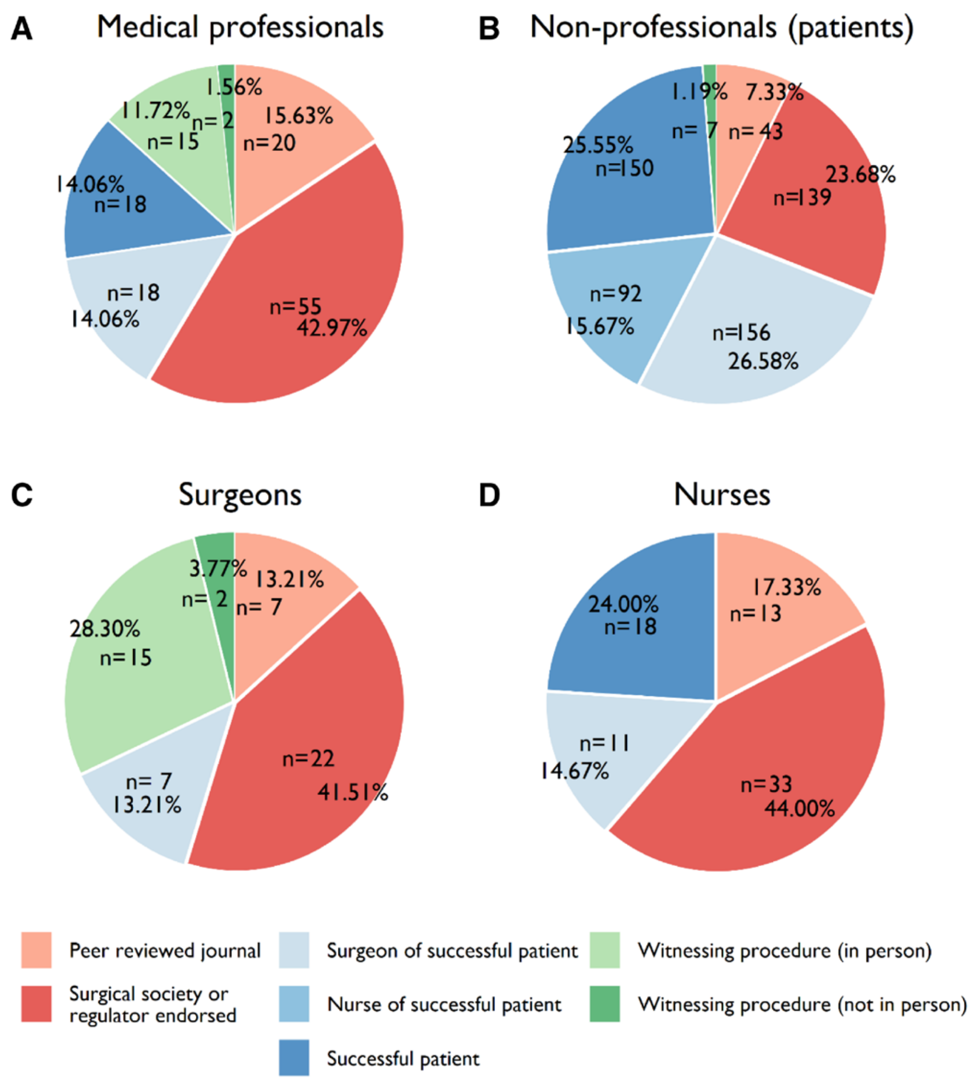

FIGURE 1. Participant preference for information regarding transition to biomaterials breast technology. A, Medical professionals (n = 128). B, Patient (n = 587). C, Surgeon (n = 53). D, Nurse (n = 75).

technology, relative to selecting successful patient. Further, when we explore the differences in response between women who chose to undergo some form of reconstruction (implant based, OR = 2.86, $P < 0.05$; tissue based, OR = 3.49, $P < 0.05$; and combination of implant and tissue, OR = 3.17, $P < 0.10$) and those that did not, we see that women who have undergone reconstruction were more likely to choose a surgeon (compared with a successful patient) when nominating their most likely information conduit for transition to a new breast technology. Both reconstruction type and choice to reconstruct findings results are robust when we control for patient demographics in Table 6, with the only exception of the combined implant- and tissues-based group.

In Table 6, we control for the variation in patient demographics such as age, BMI, education level, annual income, and private health insurance, as well as impact of both patient cancer diagnosis, and any type of postsurgery treatment.

For diagnosis type, we see that women diagnosed with lobular carcinoma in situ ($P < 0.001$) and "other" ($P < 0.001$), prefer peer-reviewed journal and nurse of successful patient, respectively. But it is important to note that both categories are very small groups in the sample population, those being 2.73% and 2.25%, respectively.

We find that older women were more likely to choose peer-reviewed journal (OR = 1.06, $P < 0.05$) or surgical society or regulator endorsed (OR = 1.04, $P < 0.05$) over a successful patient. Education also showed a positive relationship with patients' likelihood of choosing surgical society or regulator (OR = 1.25, $P < 0.05$), or peer-reviewed journal (OR = 1.88, $P < 0.05$), over the successful patient option. Finally, women who had undergone an implant-based reconstruction (OR = 4.07, $P < 0.01$) compared with those who had not undergone a reconstruction were more likely to choose nurse over patient. Similarly, women without health insurance (OR = 0.312, $P < 0.01$), were more likely to choose nurse over patient.

In Table 7, we explore any individual difference in medical professionals that impact their point of reference on adopting new breast reconstruction technologies. Interestingly, we find no statistically significant relationship between professionals' preference and their age, nor the number of other medical professionals they work with daily, or the average number of breast procedures performed in their practice on a weekly basis.

However, results show that medical professionals working exclusively in public practice were more likely to choose a surgical society or regulator (OR = 0.128, $P < 0.05$) or witnessing procedure (OR = 0.097, $P < 0.05$), compared with a successful patient.

DISCUSSION

The current standard of breast reconstruction following surgical mastectomy involves silicone implants or autologous tissue flaps, with implants being the most common method. Due to significant complication and reoperation rates using these techniques, ongoing preclinical research aims to use tissue engineering and regenerative medicine strategies to overcome these limitations. The scaffolds used in these cases normally consist of hydrogels or solid scaffolds. The advent of 3D printing, or additive manufacturing, has allowed for the creation of scaffolds containing intricate architecture that can be modeled after a patient's own anatomy. The application of such scaffolds in the clinic is imminent; however, little is known as to the potential uptake of such technologies by key stakeholders, including surgeons, nurses, and patients.

Surgeons, nurses and their patients all play a unique and, in many ways', interdependent role in the adoption of new medical technology innovations. Previous studies have explored a myriad of new health technologies adoption, such as eHealth patient records,[17–19] digital technologies,[20] home dialysis,[21] smart infusion pumps,[22] artificial intelligence,[23] telemedicine,[24] eMental health,[25] and even robotics in surgery,[26] but to name a few. As with most medical and health behavioral research, these studies have focused on the pragmatism of facilitators and barriers to actual implementation,[17,19–22,26,27] and the benefits to the patient (quality of clinical care) of any such possible transition.[25,28,29] Such research is warranted and necessary, but there exists a void of research exploring where surgeons, nurses, and patients seek information from regarding new medical technology. In the context of breast reconstruction, to the best of the authors knowledge, this study is the first of its kind to provide comparisons between these 3 key groups, and an analysis of individual patient factors impacting women's preference.

Our core findings that medical professionals state a clear preference for information sources used in their university education and professional training, such as regulatory body endorsement, peer-reviewed journals, and witnessing the procedure performed (either in person or online) is to be expected.[30] For surgeons and nurses such findings may reflect institutional and organizational protocols and processes put in place to ensure patient safety and consistency in surgical practice. However, with more fine-grained analysis of individual differences, we find no statistically significant relationship between medical professionals' preference and their age, nor the number of other medical professionals they work with daily, nor the average number of breast procedures performed in their practice on a weekly basis.

A novel finding in our study is however that patients overwhelming favor information from former successful patients. There is no question patients rely greatly on specialized diagnostic information to inform their health decision-making,[31] and research has shown an ever-increasing number of people searching for health-related information online.[32] Nevertheless, in the context of our current study, patients instead clearly gravitate towards in person or second person information from a former successful patient.

Our multivariate analysis of individual patient factors impacting women's preference also provides a unique primer for future research. All forms of mastectomy are of course a more invasive surgical procedure compared with lumpectomy. Further, choosing to undergo a reconstruction (vs choosing not to) is again, the patient choosing the more surgically invasive option. Exactly why (when comparing the more surgically invasive binary options) patients in our current sample favor dichotomous preferences for information relating to new breast technology is unclear.

TABLE 3.

Multinomial Logistic Regression Models—Choice of Information Conduit

Patient Variables	Model 1 (Table 4)	Model 2 (Table 6)
Type of reconstruction:		
Implant-based approach	✓	✓
Tissue-based approach	✓	✓
Combination tissue and implant approach	✓	✓
Type of breast cancer procedure:		
Lumpectomy	✓	✓
Mastectomy	✓	✓
Bilateral mastectomy	✓	✓
Prophylactic mastectomy	✓	✓
Diagnosis:		
ILC		✓
IDC		✓
DCIS		✓
LCIS		✓
BRCA 1,2		✓
Others		✓
No information provided		✓
Postsurgery treatment:		
Chemotherapy		✓
Radiotherapy		✓
Hormone therapy		✓
Others		✓
Patient characteristics:		
Age		✓
BMI		✓
Education level		✓
Income		✓
Private health insurance		✓

BRCA indicates breast cancer gene; DCIS ductal carcinoma in situ; IDC, invasive ductal carcinoma; ILC, invasive lobular carcinoma; LCIS, lobular carcinoma in situ.

TABLE 4.

Patients' Preferred Point of Reference on Adopting New Breast Reconstruction Biomaterials

Patient Variable	Peer-Reviewed Journal	Surgical Society or Regulator	Surgeon of Successful Patient	Nurse of Successful Patient
Reconstruction				
Implant-based approach	1.98 (0.739–5.28)	1.6 (0.78–3.28)	2.86* (1.3–6.29)	2.08† (0.886–4.89)
Tissue-based approach	1.38 (0.5–3.79)	0.981 (0.473–2.03)	3.49* (1.64–7.45)	1.17 (0.49–2.8)
Combination of both tissue and implant	2.39 (0.572–9.97)	2.29 (0.784–6.71)	3.17† (0.981–10.3)	1.96 (0.534–7.16)
Procedure				
Mastectomy	3.5 (0.408–30.1)	1.04 (0.385–2.79)	0.253* (0.0976–0.655)	0.82 (0.267–2.52)
Bilateral mastectomy	1.53 (0.165–14.2)	0.622 (0.215–1.8)	0.198* (0.072–0.546)	0.331† (0.0951–1.15)
Prophylactic Mastectomy	2.54 (0.179–36.1)	0.14† (0.0145–1.35)	0.0489‡ (0.0046–0.522)	0.386 (0.0565–2.64)
N	428			
Wald χ^2	37.2			
Probability > χ^2	0.042			
Pseudo R^2	0.030			
Log likelihood	–635.81			

Baseline comparison group: Successful patient. Reference group: Decided not to have reconstruction (reconstruction); lumpectomy (procedure).
Multinominal logit model with no control variables.
The symbols *, † and ‡ represent statistical significance at the 1%, 10%, 5%, and 0.1% levels, respectively.

TABLE 5.

Patients' Preferred Point of Reference on Adopting New Breast Reconstruction Biomaterials

Patient Variable	Peer-Reviewed Journal	Surgical Society or Regulator	Surgeon of Successful Patient	Nurse of Successful Patient
Reconstruction				
Implant-based approach	2.92* (0.909–9.35)	1.79 (0.827–3.87)	2.59† (1.12–5.98)	2.99† (1.12–8)
Tissue-based approach	2.38 (0.727–7.77)	1.25 (0.571–2.73)	3.74‡ (1.67–8.39)	1.5 (0.549–4.13)
Combination of both tissue and implant	2.8 (0.516–15.2)	2.37 (0.754–7.47)	1.56 (0.383–6.39)	2.95 (0.711–12.2)
Procedure				
Mastectomy	1.81 (0.197–16.7)	0.89 (0.296–2.68)	0.253† (0.0864–0.739)	0.585 (0.164–2.08)
Bilateral mastectomy	0.684 (0.0676–6.93)	0.412 (0.127–1.34)	0.188‡ (0.0604–0.587)	0.176† (0.0418–0.74)
Prophylactic mastectomy	1.74 (0.107–28.3)	0.125* (0.0115–1.36)	0.0684† (0.0057–0.827)	0.283 (0.0339–2.36)
N	368			
Wald χ^2	38.7			
Probability > χ^2	0.029			
Pseudo R^2	0.036			
Log likelihood	–538.60			

Baseline comparison group: Successful patient.
Multinominal logit model with no control variables (restricted to nonmissing variables as above).
The symbols *, † and ‡ represent statistical significance at the 5%, 10%, 1%, and 0.1% levels, respectively.

TABLE 6.

Patients' Preferred Point of Reference on Adopting New Breast Reconstruction Biomaterials

Patient Variable	Peer-Reviewed Journal	Surgical Society or Regulator	Surgeon of Successful Patient	Nurse of Successful Patient
Reconstruction				
Implant-based approach	5.13* (1.38–19.1)	2.58* (1.05–6.3)	3.61* (1.34–9.76)	3.09† (0.98–9.73)
Tissue-based approach	4.09* (1.18–14.2)	1.66 (0.711–3.87)	4.66‡ (1.81–12)	1.6 (0.564–4.56)
Combination of both tissue and implant	4.69 (0.673–32.6)	3.65* (1.13–11.9)	2.07 (0.478–8.93)	4.22† (0.823–21.6)
Procedure				
Mastectomy	1.69 (0.207–13.8)	0.914 (0.277–3.01)	0.229* (0.0637–0.821)	0.425 (0.0967–1.86)
Bilateral mastectomy	0.931 (0.113–7.7)	0.52 (0.149–1.81)	0.186* (0.0508–0.681)	0.108‡ (0.022–0.531)
Prophylactic mastectomy	1.78 (0.0482–65.5)	0.143 (0.0132–1.56)	0.0697* (0.0063–0.778)	0.229 (0.0276–1.9)
Diagnosis				
ILC	0.362 (0.0885–1.48)	0.669 (0.256–1.75)	0.44 (0.156–1.24)	1.28 (0.38–4.3)
IDC	0.416 (0.109–1.59)	0.968 (0.427–2.19)	0.631 (0.268–1.49)	1.1 (0.386–3.16)
LCIS	4.4×10^{-07}§ (5.2×10^{-08}–3.7×10^{-06})	0.955 (0.104–8.8)	0.539 (0.0696–4.18)	4.05 (0.536–30.6)
BRCA 1,2	3.26 (0.268–39.7)	2.15 (0.422–10.9)	1 (0.18–5.6)	0.2 (0.0207–1.94)
Others	3.28 (0.154–69.6)	4.43 (0.421–46.5)	4.43 (0.322–60.8)	3.4×10^{-06}§ (3.6×10^{-07}–3.1×10^{-05})
No information provided	0.725 (0.118–4.45)	1.48 (0.491–4.48)	0.514 (0.161–1.64)	1.02 (0.272–3.85)
Postsurgery treatment				
Chemotherapy	0.65 (0.213–1.98)	0.737 (0.36–1.51)	1.41 (0.645–3.08)	1.98 (0.724–5.39)
Radiotherapy	0.856 (0.305–2.4)	1.2 (0.565–2.54)	0.914 (0.44–1.9)	0.412† (0.144–1.18)
Hormone therapy	1.11 (0.412–3)	1.1 (0.53–2.29)	0.849 (0.417–1.73)	0.767 (0.324–1.81)
Others	0.643 (0.194–2.13)	0.674 (0.296–1.53)	0.561 (0.23–1.37)	1.29 (0.435–3.81)
Controls				
Age	1.08‡ (1.02–1.14)	1.04* (1.01–1.08)	1.03† (0.997–1.07)	1.01 (0.966–1.05)
BMI	1.05 (0.968–1.13)	0.988 (0.938–1.04)	1.03 (0.972–1.09)	1.07† (1–1.15)
Education	2* (1.04–3.85)	1.26* (1.03–1.53)	1.09 (0.884–1.33)	1.12 (0.876–1.44)
ln(personal income)	2.07† (0.952–4.5)	0.931 (0.65–1.33)	0.788 (0.548–1.14)	0.697 (0.442–1.1)
Private insurance	1.68 (0.545–5.18)	1.06 (0.553–2.02)	1.08 (0.558–2.07)	0.331‡ (0.148–0.743)
N	368			
Wald χ^2	2490.2			
Probability > χ^2	0.000			
Pseudo R^2	0.122			
Log likelihood	–490.85			

Baseline comparison group: Successful patient. Reference group: Decided not to have reconstruction (reconstruction); lumpectomy (procedure); DCIS (diagnosis). For medical diagnosis, others include Paget's disease of the breast (n = 2), phyllodes tumor of the breast (n = 2), and inflammatory breast cancer (n = 10). No information provided includes I do not know (n = 41) and I do not remember (n = 43).
Multinominal logit model with control variables.
The symbols *, †, ‡, and § represent statistical significance at the 5%, 10%, 1%, and 0.1% levels, respectively.
BRCA indicates breast cancer gene; DCIS, ductal carcinoma in situ; IDC, invasive ductal carcinoma; ILC, invasive lobular carcinoma; LCIS, lobular carcinoma in situ.

Limitations

The current study is not without limitations. Firstly, for scientific simplicity participants were offered mutually exclusive choices for this study. Large-scale medical decision-making obviously involves a far more nuanced and complex interaction of factors impacting choice. Therefore, any increase in contributing factors or option alternatives can lead to decision difficulties.[33] Secondly, and again for scientific simplicity our participants were asked to select their most favored option. Future research should be designed to instead ask participants for ordinal ranks or a possible weighting system for categorical options for greater evaluation and comparison. Thirdly, our study provides

TABLE 7.

Medical Professional Preferred Point of Reference on Adopting New Breast Reconstruction Biomaterials

Professional Variable	Peer-Reviewed Journal	Surgical Society or Regulator	Surgeon of Successful Patient	Witnessing Procedure
Age	0.993 (0.92–1.07)	0.965 (0.898–1.04)	0.993 (0.913–1.08)	0.976 (0.891–1.07)
Practice setting				
Public	0.222 (0.0316–1.56)	0.128* (0.0216–0.756)	0.382 (0.053–2.75)	0.0973* (0.0132–0.716)
Evenly between both	0.212 (0.0111–4.05)	0.244 (–.0274–2.18)	0.964 (0.0863–10.8)	0.21 (0.0175–2.51)
Specialist peers				
One	0.303 (0.0204–4.51)	3.65 (–.559–23.8)	6.36† (0.742–54.5)	1.17 (0.0857–16)
Two	2.58 (0.161–41.3)	3.16 (0.181–55.4)	5.7 (0.223–146)	1.25 (0.046–33.9)
Three	0.228 (0.0146–3.58)	0.408 (0.0482–3.46)	1.16 (0.0598–22.5)	0.592 (0.0223–15.7)
Four	1.15 (0.0807–16.4)	0.365 (0.0224–5.95)	2.78 (0.116–66.7)	14.6† (0.677–313)
Five +	0.405 (0.0339–4.84)	0.742 (0.109–5.03)	6.24 (0.563–69.3)	1.49 (0.163–13.6)
Breast procedures pw				
0	1.1 (0.122–9.98)	0.401 (0.0838–1.92)	0.648 (0.107–3.91)	
6–10	3.82 (0.324–45.1)	0.87 (0.121–6.24)	0.924 (0.0963–8.86)	2.44 (0.313–19)
10+	14.5* (1.21–174)	5.17 (0.721–37.1)	0.75 (0.0504–11.1)	2.21 (0.207–23.6)
N	124			
Wald χ^2	1202.4			
Probability > χ^2	0.000			
Pseudo R^2	0.165			
Log likelihood	–154.48			

Baseline comparison group: Successful patient. Reference group: Private practice; no specialist peers; 1–5 breast procedures per week.
The symbols * and † represent statistical significance at the 5%, 10%, 1%, and 0.1% levels, respectively.
Multinominal logit model with control variables.
pw indicates per week.

participants stated preference (as opposed to actual choice outcomes, that is their revealed preference), which has been shown to be a poor indicator of actual behavior, particularly in online settings.[34] That said, with no current biocompatible 3D printed bioresorbable implant alternative currently clinically available, stated preference is the only research method possible. Finally, the current study was stated to participants in a way that framed new breast implant technologies as being a superior procedure to current silicone implants and reconstructions using patients own tissue. The baseline assumption that the new technology was superior, although necessary for consideration as an alternative, plays some role in framing and shaping participants preference. With any new medical innovation or surgical procedure, it is important to recognize that "a new technique is not necessarily a better one."[28] As such, future research should focus on how to understand not only weight of preference for information substitutions, but comparative risk and benefits information contextualized for both current and possible future medical technologies. Such findings could inform the development and testing of practical patient-centered strategies like decision aids or vignettes from former successful patients.

CONCLUSIONS

The processes that determine whether and how technological innovations are adopted and integrated into routine health practice are likely dependent on the complexity of the innovation in question,[35] which can make them difficult to understand. Certainly, researchers have argued that "adoption & assimilation" of new medical technologies is better viewed as an evolving process than a particular discrete event.[35] That said, human beings have preferences, and these preferences inform our decision-making. The evolution and implementation of any new medical technology then, at its simplest, is just the sequential summation of our preference influencing decisions across time. Where we choose to seek information from to inform our preference is thus of critical importance. How surgeons, nurses, and patients prefer to seek information on new biomedical technologies is currently ambiguous. Our analysis shows such variation between these three unique but important groups preference for information warrants future behavioral research.

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