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Literacy disparities in patient access and health-related use of Internet and mobile technologies

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Abstract

Background Age and race-related disparities in technology use have been well documented, but less is known about how health literacy influences technology access and use.

Objective To assess the association between patients' literacy skills and mobile phone ownership, use of text messaging, Internet access, and use of the Internet for health-related purposes.

Methods A secondary analysis utilizing data from 1077 primary care patients enrolled in two, multisite studies from 2011–2013. Patients were administered an in-person, structured interview.

Results Patients with adequate health literacy were more likely to own a mobile phone or smartphone in comparison with patients having marginal or low literacy (mobile phone ownership: 96.8 vs. 95.2 vs. 90.1%, respectively, $P < 0.001$; smartphone ownership: 70.6 vs. 62.5 vs. 40.1%, $P < 0.001$) and to report text messaging (78.6 vs. 75.2 vs. 53.1%, $P < 0.001$). They were also more likely to have access to the Internet from their home (92.1 vs. 74.7 vs. 44.9%, $P < 0.001$) and to report using the Internet for email (93.0 vs. 75.7 vs. 38.5%, $P < 0.001$), browsing the web (93.9 vs. 80.2 vs. 44.5%, $P < 0.001$), accessing health information (86.3 vs. 75.5 vs. 40.8%, $P < 0.001$), and communicating with providers (54.2 vs. 29.8 vs. 13.0%, $P < 0.001$). Relationships remained significant in multivariable analyses controlling for relevant covariates.

Conclusions Results reveal that literacy-related disparities in technology access and use are widespread, with lower literate patients being less likely to own smartphones or to access and use the Internet, particularly for health reasons. Future interventions should consider these disparities and ensure that health promotion activities do not further exacerbate disparities.

Background

The rise in health information technology has created new avenues for communicating with patients and delivering care. An increasing number of patients now have the capability of electronically accessing their medical records, contacting their provider, scheduling clinic appointments and requesting prescription medication refills via patient portals.[1,2] Beyond formal health-care settings, patients also have increased access to health information and support via the Internet and mobile technologies. Hundreds of thousands of mobile applications exist to help patients improve their health, from self-managing medications to losing weight.[3,4] Similarly, websites and online discussion forums can provide valuable health information and emotional support for patients coping with complex health conditions.[5–7]

Recent studies suggest that the expanded role of health technology has positively influenced health-care quality, efficiency and satisfaction.[8,9] However, concerns remain over unequal access to such technology and its potential to further exacerbate health disparities. Historically, studies have shown lower use and access to health information technology among racial/ethnic minority groups, the socioeconomically disadvantaged and the elderly.[10–13] Yet, the rapid rise of mobile technology may reduce some of these disparities. A recent national survey conducted by the Pew Research Center found similar, high rates of mobile phone ownership between White, Black and Hispanic adults.[14,15] Results also indicated that minority adults are increasingly using their mobile phones for Internet access and an ever-expanding range of activities. Specifically, Black and Hispanic respondents reported greater use of mobile phones to send emails, access the Internet and download mobile applications in comparison to White adults. Despite this growing adoption of mobile phone technology among racial/ethnic minority groups, other disparities remain, with mobile phone ownership and use still highest among younger adults and those of higher socioeconomic status.[15] Evidence also suggests that age and education-related disparities exist in terms of using smartphone technology and the Internet to access health information and communicate with health-care providers.[16,17]

While race, socioeconomic and age-related trends in technology use have been well documented, less is known about how health literacy may currently influence adults' access and use of the Internet and mobile technology, particularly for health-related purposes. Health literacy is commonly defined as an individual's ability to obtain, process and understand the health information needed to make informed health decisions.[18] It differs from basic literacy in that it focuses specifically on the application of skills within a health-care context; it is also generally conceptualized as encompassing a broader range of competencies than reading ability alone.[18] Gaining an understanding of the relationship between health literacy and the use of various technologies would help elucidate potential avenues of intervention and determine optimal platforms for communicating health-related information to this at-risk population. This study sought to take advantage of a unique opportunity to examine the relationship between health literacy and technology use among a large, diverse sample of adults from two geographically distinct regions of the United States. Findings can provide valuable guidance on the future development of health literacy-informed interventions.

Methods

A secondary analysis was conducted utilizing data from a National Institute of Aging study entitled 'Health Literacy and Cognitive Function among Older Adults' (R01AG030611, referred to as 'LitCog'), and a study on patient understanding of acetaminophen instructions funded by an unrestricted research grant from McNeil Consumer Healthcare. Institutional Review Boards at Northwestern University, Emory University, Mercy Hospital (Chicago) and Grady Hospital (Atlanta) approved these studies.

Setting and participants

English-speaking, adult patients were recruited from five community health centres and one academic general internal medicine clinic in Chicago, IL (LitCog and McNeil). In Atlanta, patients were recruited from general internal medicine clinics at one academic medical centre and one public hospital (McNeil only). Recruitment for LitCog occurred from November 2011 through September 2013 while recruitment for the McNeil study took place between August 2012 and February 2013. A full description of the systematic recruitment procedures for each of these studies has been published elsewhere.[19,20]

Patients were eligible to participate in the McNeil study if they: (i) spoke English, (ii) were ages 18–80 and (iii) lacked any hearing, visual or cognitive impairment that would preclude informed consent or study participation. Patients in the LitCog study were eligible if they met the above criteria, with the exception of a stricter age requirement (age 55–74 at enrolment). Participants in both studies were engaged in the informed consent process, then administered a structured, in-person interview by a trained research assistant (RA) in a private area.

Measures

Participants in the LitCog study completed two study interviews 7–10 days apart; the focus of the 2-h interviews was to complete a series of cognitive assessments. For the McNeil study, patient interviews lasted less than an hour and primarily assessed patients' ability to interpret dosage instructions for 'as-needed' medications. Additional details on the data captured in both of these studies have been published previously.[19,20]

Patient literacy skills were assessed in both studies using the Newest Vital Sign (NVS), a 6-item numeracy and literacy test that asks patients to interpret information provided on a standard nutrition label.[21] Based upon the results of this assessment, patients were classified as either 'high likelihood of limited literacy', 'possibility of limited literacy' or 'adequate literacy'. For the sake of simplicity, these groups are referred to as 'low, marginal and adequate' literacy skills, respectively. A series of structured questions were then administered in both studies to assess technology use; specifically, questions inquired about mobile phone ownership and use, access to and use of the Internet (at home and/or anywhere), communication with health-care providers via the Internet and use of the Internet to access health information. In addition, patients were asked standardized questions regarding their socio-demographic characteristics, including household income, race/ethnicity, age, sex and level of education.

Analyses

Descriptive statistics were calculated for variables measuring patients' socio-demographic characteristics and technology use. Bivariate analyses were conducted for all technology questions by literacy level using chi-squared tests. Multivariate logistic regression models were then conducted to examine determinants of smartphone ownership, Internet access in the home and using the Internet to access health information or communicate with a health-care provider. Age, sex, race and income were included in all models as covariates. All analyses were performed using STATA 12.0 (College Station, TX, USA).

Results

Of the 1103 individuals recruited for both studies, 1077 (97.6%) completed both the NVS and technology questions and were included in analyses ($n = 441$ in LitCog and $n = 636$ in McNeil). Table 1 describes the socio-demographic characteristics of the total study sample. Overall, study patients varied greatly in regard to education, race/ethnicity and income. On average, patients were 55 years old; slightly more than half were African American, two-thirds were female and 42.4% had an annual household income below

Table 1 Characteristics of the study sample

Variable	All participants (N = 1077)	Health literacy			P value
		Low (n = 344)	Marginal (n = 290)	Adequate (n = 443)	
Age and Mean (SD)	54.7 (15.4)	56.3 (13.4)	53.3 (16.6)	54.8 (15.9)	0.05
Age (%)					<0.001
18–30	11.2	5.8	14.9	12.9	
31–45	14.8	11.9	16.2	16.0	
45–64	44.0	53.5	38.8	40.2	
≥65	30.0	28.8	30.1	30.9	
Male (%)	34.6	41.3	33.5	30.3	0.005
Race (%)					<0.001
Black	55.5	80.2	63.1	31.4	
White	34.1	8.5	26.9	58.7	
Other	10.4	11.3	10.0	9.9	
Education (%)					<0.001
High School or less	36.2	67.9	37.9	10.9	
Some college	24.3	21.2	28.6	23.8	
≥College graduate	39.5	10.9	33.5	65.3	
Income (%)					<0.001
<$20 000	42.4	72.8	44.9	18.7	
$20 000–$50 000	24.8	19.1	29.6	25.8	
>$50 000	32.8	8.1	25.5	55.5	

$20 000. One-third of patients (31.9%) were classified as having low literacy according to NVS criteria.[21] Low and marginal literacy skills were significantly associated with age, sex, race, education and income (Table 1). Patients in the LitCog study were predominately recruited from an academic practice setting; these patients were significantly less likely to have limited literacy skills than other study patients.

Bivariate analyses exploring the relationship between literacy skills and mobile phone ownership revealed patients with adequate literacy were significantly more likely to own a mobile phone or smartphone in comparison with patients having marginal or low literacy skills (mobile phone ownership: 96.8 vs. 95.2 vs. 90.1%, respectively, $P < 0.001$; smartphone ownership: 70.6 vs. 62.5 vs. 40.1%, $P < 0.001$; Table 2). Individuals with adequate health literacy were also significantly more likely to report sending or receiving text messages and having a text message plan than those with marginal or low literacy (using text messaging: 78.6 vs. 75.2 vs. 53.1%, respectively, $P < 0.001$; text message plan: 79.9 vs. 74.4 vs. 59.7%, $P < 0.001$). Among patients who had a text message plan, there were no significant differences by literacy skills for enrollment in an unlimited text message plan.

Bivariate analyses examining the relationship between literacy skills and Internet use similarly identified key differences (Table 2). Patients with adequate health literacy skills were more likely to have access to the Internet from their home or from anywhere in comparison with patients having marginal or low literacy skills. Individuals with adequate health literacy skills were also more likely than their counterparts to report using the Internet for email (93.0 vs. 75.7 vs. 38.5%, $P < 0.001$), for browsing the Web (93.9 vs. 80.2 vs. 44.5%, $P < 0.001$), to access health information (86.3 vs. 75.5 vs. 40.8%, $P < 0.001$) and to communicate with health-care providers (54.2 vs. 29.8 vs. 13.0%, $P < 0.001$; Table 2).

In multivariable analyses, low literacy, older age and lower income levels were all significant, independent predictors of not owning a smartphone (Table 3). Additionally,

Table 2 Bivariate analyses of mobile phone use and Internet use by health literacy

Variable	All participants (N = 1077)	Health literacy			P value
		Low (n = 344)	Marginal (n = 290)	Adequate (n = 443)	
Mobile phone ownership and use					
Owns a mobile phone (%)	94.3	90.1	95.2	96.8	<0.001
Owns a smart phone (%)	59.2	40.1	62.5	70.6	<0.001
Texts (%)	69.9	53.1	75.2	78.6	<0.001
Has a text message plan (%)	72.4	59.7	74.4	79.9	<0.001
Has an unlimited text plan[1] (%)	81.8	83.0	83.9	79.9	0.471
Internet access and use					
Access to Internet in home (%)	72.6	44.9	74.7	92.1	<0.001
Access to Internet anywhere (%)	86.8	68.2	90.6	98.2	<0.001
Use Internet for Email (%)	71.3	38.5	75.7	93.0	<0.001
Use Internet for browsing the Web (%)	74.8	44.5	80.2	93.9	<0.001
Use Internet to access health information (%)	70.3	40.8	75.5	86.3	<0.001
Use Internet to communicate with health care providers (%)	35.7	13.0	29.8	54.2	<0.001

[1]Among those with a text plan.

participants who identified themselves as non-White were more likely to own a smartphone than White adults. For the outcome of Internet access at home, low and marginal literacy, ages 65 and older and lower income levels were independently predictive of not having Internet access. Similarly, low literacy, older age, male gender and an income <$20 000 annually were all significant predictors of not accessing health information via the Internet. Finally, low or marginal literacy (low: OR 2.67, 95% CI 1.66–4.29; marginal: OR 1.62, 95% CI 1.12–2.35), ages 65 and older (OR 1.77, 95% CI 1.02–3.06), non-White race (*Black*: OR: 2.5, 95% CI 1.66–3.76; *Other race*: OR 2.21, 95% CI 1.28–3.83) and lower income levels (< $20 000: OR 4.72, 95% CI 2.99–7.43; $20 000–$50,000: OR 1.79, 95% CI 1.21–2.65) were all independently associated with not communicating with health-care providers electronically.

Discussion

Study findings reveal that a digital divide exists among individuals with limited versus adequate literacy skills, with lower literate patients being less likely to own smartphones or to access and use the Internet, particularly for health-related purposes. As society increasingly relies on these technologies for rapid communication, individuals with limited literacy skills may become even further isolated, exacerbating the health inequities experienced by this group. These findings highlight that limited literacy, independent of age and socioeconomic factors such as education and household income, poses a significant risk for lower access and health-related use. Therefore, remaining attentive to literacy disparities in technology access and use is essential to ensure equal access to health information and services.

As recognized in several prior health literacy studies, it is challenging to untangle the contributions of ageing, socioeconomic status and literacy skills on various health behaviours and outcomes.[22–24] Generational differences in technology use could plausibly be explained by habit and hesitancy to adopt less familiar tools, such as smartphones or the Internet. Socioeconomic barriers likely reflect poor financial access and affordability of what are often expensive devices and service plans. For literacy, these issues are also likely present, but in addition, it is possibly that a lack of proficiency or 'technology literacy' explains differences in access and use. Understanding

Table 3 Multivariable predictors of lack of technology use

	Do not own a smartphone			No Internet in home			Do not access health information via Internet			Do not communicate with health-care provider via Internet		
Variable	AOR	95% CI	*P* value	AOR	95% CI	*P* value	AOR	95% CI	*P* value	AOR	95% CI	*P* value
Literacy evel												
Adequate	1.00			1.00			1.00			1.00		
Marginal	1.32	0.90–1.93	0.16	2.14	1.32–3.47	0.002	1.47	0.95–2.27	0.09	1.62	1.12–2.35	0.01
Low	2.52	1.66–3.83	<0.001	4.85	3.02–7.79	<0.001	4.19	2.69–6.54	<0.001	2.67	1.66–4.29	<0.001
Age group												
18–30	1.00			1.00			1.00			1.00		
31–45	2.01	0.94–4.30	0.07	0.72	0.35–1.45	0.35	2.06	0.99–4.27	0.054	1.19	0.66–2.14	0.56
45–64	6.23	3.19–12.2	<0.001	1.57	0.87–2.84	0.13	2.82	1.48–5.37	0.002	1.03	0.62–1.72	0.90
≥65	15.76	7.81–30.8	<0.001	2.42	1.27–4.61	0.007	3.91	1.97–7.73	<0.001	1.77	1.02–3.06	0.04
Gender												
Female	1.00			1.00			1.00			1.00		
Male	1.01	0.74–1.37	0.96	1.34	0.94–1.92	0.11	1.60	1.13–2.25	0.008	1.06	0.77–1.49	0.70
Race												
White	1.00			1.00			1.00			1.00		
Black	0.56	0.36–0.88	0.01	1.69	0.99–2.88	0.06	1.35	0.86–2.21	0.23	2.50	1.66–3.76	<0.001
Other	0.48	0.27–0.88	0.02	1.42	0.71–2.87	0.32	1.25	0.66–2.36	0.50	2.21	1.28–3.83	0.005
Income												
>$50 000	1.00			1.00			1.00			1.00		
$20 000–$50 000	2.36	1.52–3.65	<0.001	2.83	1.49–5.36	0.001	0.93	0.55–1.58	0.80	1.79	1.21–2.65	0.004
< $20 000	3.87	2.42–6.19	<0.001	8.53	4.59–15.9	<0.001	3.12	1.90–5.12	<0.001	4.72	2.99–7.43	<0.001

AOR, Adjusted Odds Ratio adjusted for all variables shown; CI, confidence interval.

the root cause(s) of lower access and use among limited literate patients is paramount to design effective health promotion interventions. These interactive communication and information tools may not be the best modalities in the near future for health communication for patients that do not already use them or have chosen against adoption. It also may be cost prohibitive or of limited benefit from a health system perspective to rely upon mobile technologies and/or portal use to communicate with, or support the health needs of, a predominately low-literate patient population. However, it is also possible that something as straightforward as offering a clear orientation to mobile and portal technology and its specific functions could help close the gap on literacy inequities. Additional research is needed to determine how to address these disparities in the most effective manner.

Study findings, while highlighting the literacy disparities, also offer insight on how some health information technology may potentially be leveraged to promote positive health-care engagement among adults with limited literacy skills. According to study results, mobile phone ownership is pervasive in this population, with more than 90% of individuals with low or marginal literacy reporting that they own a mobile phone and over half (53.1%) stating that they send or receive text messages. This suggests that interventions using text messaging may be appropriate for some members of this population, although older adults with limited literacy may still need to be oriented to the process. Furthermore, as 72.4% of adults in this study had a text message plan (which was often unlimited), utilizing text messaging for health promotion purposes is unlikely to pose a financial burden for many patients. In contrast, smartphone-based interventions (i.e. mobile applications) or those which require Internet access, particularly in the privacy of a home (i.e. patient portal-based interventions), are unlikely to be as well-suited to lower literate patients.

There are limitations to this study that should be noted. First, findings are based upon patient self-report; technology use was not verified by research staff, nor were staff able to ascertain whether patients shared mobile phones with others, a finding from other studies among underserved populations.[25] Second, data are from two study cohorts and were collected at different times, while within a 2-year span, and with different eligibility criteria (by age) for participants. Despite this being recent data collection, estimates may still be low given the steady rise in technology access and use that has been recorded longitudinally. Only English-speaking patients were included in the study; it is possible that results would differ among groups speaking a language other than English. Finally, one's complete health information-seeking behaviour, beyond these technologies, was not investigated, nor was their actual knowledge of their personal health. Therefore, it was impossible to examine whether lower access and utilization of Internet and mobile technologies had a negative impact on patients' acquisition of health information or health outcomes; investigators also could not tease apart the individual impact of various types of technology on outcomes.

There seems to be sufficient evidence to warrant the concerns by many health-care researchers and professionals of literacy-related technology disparities. With the increasing uptake of health technologies and corresponding greater expectations that patients interact with the Internet and mobile devices, patients with limited literacy may not get a proportional benefit compared to those with adequate literacy skills. As the mobile health field is increasingly seeking to utilize technology to improve health behaviour and outcomes, health literacy-related disparities in mobile phone and Internet use could have major ramifications. Moving forward, while generational and financial barriers may not be as easily remediated, health literacy best practices for the design of multimedia information and interventions should be incorporated in the design of websites, portals and mobile applications.[26] Additionally, training and technical support resources have recently been developed and found to benefit both older and lower literate patients.[26–28] Health systems should

consider these to be a requisite part of any new patient-designed technology toolkit to minimize potential literacy differences.

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References

1 Hsiao CJ, Hing E. Use and characteristics of electronic health record systems among office-based physician practices: United States, 2001-2013. *NCHS Data Brief*, 2014; **143**: 1–8.
2 Goel MS, Brown TL, Williams A, Cooper AJ, Hasnain-Wynia R, Baker DW. Patient reported barriers to enrolling in a patient portal. *Journal of the American Medical Informatics Association*, 2011; **18**(Suppl 1): i8–i12.
3 Bailey SC, Belter LT, Pandit AU, Carpenter DM, Carlos E, Wolf MS. The availability, functionality, and quality of mobile applications supporting medication self-management. *Journal of the American Medical Informatics Association*, 2014; **21**: 542–546.
4 Bacigalupo R, Cudd P, Littlewood C, Bissell P, Hawley MS, Buckley Woods H. Interventions employing mobile technology for overweight and obesity: an early systematic review of randomized controlled trials. *Obesity Reviews*, 2013; **14**: 279–91.
5 Vaughan Sarrazin MS, Cram P, Mazur A, Ward M, Reisinger HS. Patient perspectives of dabigatran: analysis of online discussion forums. *The Patient*, 2014; **7**: 47–54.
6 Thoren EM, Metze B, Buhrer C, Garten L. Online support for parents of preterm infants: a qualitative and content analysis of Facebook 'preemie' groups. *Archives of Disease in Childhood. Fetal and Neonatal Edition*, 2013; **98**: F534–F538.
7 Griffiths KM, Calear AL, Banfield M. Systematic review on Internet Support Groups (ISGs) and depression (1): do ISGs reduce depressive symptoms? *Journal of Medical Internet Research*, 2009; **11**: e40.
8 King J, Patel V, Jamoom EW, Furukawa MF. Clinical benefits of electronic health record use: national findings. *Health Services Research*, 2014; **49**(1 Pt 2): 392–404.
9 Zhou YY, Kanter MH, Wang JJ, Garrido T. Improved quality at Kaiser Permanente through e-mail between physicians and patients. *Health Affairs*, 2010; **29**: 1370–1375.
10 Goel MS, Brown TL, Williams A, Hasnain-Wynia R, Thompson JA, Baker DW. Disparities in enrollment and use of an electronic patient portal. *Journal of General Internal Medicine*, 2011; **26**: 1112–1116.
11 Roblin DW, Houston TK 2nd, Allison JJ, Joski PJ, Becker ER. Disparities in use of a personal health record in a managed care organization. *Journal of the American Medical Informatics Association*, 2009; **16**: 683–689.
12 Miller H, Vandenbosch B, Ivanov D, Black P. Determinants of personal health record use: a large population study at Cleveland Clinic. *Journal of Healthcare Information Management*, 2007; **21**: 44–48.

13 Ancker JS, Barron Y, Rockoff ML *et al*. Use of an electronic patient portal among disadvantaged populations. *Journal of General Internal Medicine*, 2011; **26**: 1117–1123.
14 Pew Research Center. Mobile technology fact sheet. 2013. Available at: http://www.pewinternet.org/fact-sheets/mobile-technology-fact-sheet, accessed 16 March 2014.
15 Duggan M. *Cell Phone Activities 2013*. Pew Research Center. Available at http://www.pewinternet.org/2013/09/19/cell-phone-activities-2013, accessed 16 March 2014.
16 Fox S, Duggan M. *Mobile Health 2012*. Pew Research Center. Available at http://www.pewinternet.org/2012/11/08/mobile-health-2012, accessed 16 March 2014.
17 Schickedanz A, Huang D, Lopez A *et al*. Access, interest, and attitudes toward electronic communication for health care among patients in the medical safety net. *Journal of General Internal Medicine*, 2013; **28**: 914–920.
18 Institute of Medicine. *A Prescription to End Confusion*. Washington, DC: National Academies Press, 2004.
19 Wolf MS, Curtis LM, Wilson EA *et al*. Literacy, cognitive function, and health: results of the LitCog Study. *Journal of General Internal Medicine*, 2012; **27**: 1300–1307.
20 Wolf MS, King J, Jacobson K *et al*. Risk of unintentional overdose with non-prescription acetaminophen products. *Journal of General Internal Medicine*, 2012; **27**: 1587–1593.
21 Weiss BD, Mays MZ, Martz W *et al*. Quick assessment of literacy in primary care: the newest vital sign. *Annals of Family Medicine*, 2005; **3**: 514–522.
22 Wolf MS, Gazmararian JA, Baker DW. Health literacy and functional health status among older adults. *Archives of Internal Medicine*, 2005; **165**: 1946–1952.
23 Paasche-Orlow MK, Parker RM, Gazmararian JA, Nielsen-Bohlman LT, Rudd RR. The prevalence of limited health literacy. *Journal of General Internal Medicine*, 2005; **20**: 175–184.
24 DeWalt DA, Berkman ND, Sheridan S, Lohr KN, Pignone MP. Literacy and health outcomes: a systematic review of the literature. *Journal of General Internal Medicine*, 2004; **19**: 1228–1239.
25 Gazmararian JA, Elon L, Yang B, Graham M, Parker R. Text4baby program: an opportunity to reach underserved pregnant and postpartum women? *Maternal and Child Health Journal*, 2014; **18**: 223–232.
26 Broderick JP, Devine T, Langhans E, Lemerise AJ, Lier S, Harris L. Designing health literate mobile apps. Discussion Paper, Institute of Medicine, Washington, DC. 2014. Available at: http://www.iom.edu/Global/Perspectives/2014/HealthLiterateApps.aspx, accessed 16 March 2014.
27 Belle SH, Burgio L, Burns R *et al*. Enhancing the quality of life of dementia caregivers from different ethnic or racial groups: a randomized, controlled trial. *Annals of Internal Medicine*, 2006; **145**: 727–738.
28 Rogers WA, Campbell RH, Pak R. A systems approach for training older adults to use technology. In: Charness N, Park DC, Sabel BA (eds) *Communication, Technology, and Aging: Opportunities and Challenges for the Future*. New York: Springer, 2001: 187–208.