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Determinants of ICT usage for healthcare among people with disabilities: The moderating role of technological and behavioural constraints

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ABSTRACT

Existing studies have demonstrated that people with disabilities (PwD) face a range of technological and behavioural barriers to successful adoption of information and communication technology (ICT)-enabled health services. However, there has been little examination and no scholarly consensus on the relative impact of each factor. This study investigates the determinants of ICT usage for health care among PwD. Using national-level disability survey data in Australia, several multivariate hierarchical regression models are deployed to predict the relationship between ICT-enabled health service adoption and the explanatory variables. In addition, several measures of the overall goodness-of-fit are estimated for each model. The results indicate that age, gender, income, level of education, language proficiency and geographical remoteness are significant predictors of ICT-enabled health care usage among PwD. It is also found that technological constraints have a stronger moderating effect than behavioural factors. This provides valuable insight for policymakers and private organisations on which approaches and interventions are most likely to narrow the digital disability divide.

1. Introduction

A large volume of published studies have concluded that information and communication technologies (ICTs), particularly Internet access, play a major role in increasing the well-being and capabilities of people with disabilities (PwD) [23,39,44]. Approximately 15% of the world's population suffers from some type of disability, and this figure is projected to increase with the aging population of many societies [28]. In Australia, almost one in five people report some form of disability [1]. ICT assists PwD by enabling the creation of new social relations [12], tapping into resources of health information [15,26,32], empowering PwD with a sense of autonomy [14], improving health outcomes and lowering health care costs [22,34].

Disability also presents a number of barriers to the successful adoption of ICT. Research has shown the digital divide in general to be a complex and multidimensional phenomenon [6], and one key result to emerge is that the divide is particularly wide between people with and without disabilities [7,16,17,33,39]. For example, 84.6% of the Australian population are Internet users [20]compared to only 64.3% of Australian PwD [1]. This has been termed as the 'digital disability divide' in several recent studies [16,33]. Empirical work has looked at the factors which have shaped this divide [15,16,17,31,33], but few studies have focused specifically on the determinants of ICT-enabled health service adoption among PwD. For example, studies have examined current practices and future strategies in accessing and using ICT-based health information services, such as telehealth and mobile health care adoption [9,19,25].

Existing studies have revealed several specific economic and technological constraints which impede the capacity of PwD to make use of technology in their everyday lives. Numerous studies have found that the monetary costs of purchasing equipment and subscribing to broadband services present major affordability barriers for PwD [15,23,26,39]. Lack of access, skill and knowledge limitations, and poor service quality have been reported as the most prominent barriers to ICT usage among PwD [8,15,16,38]. Several studies have also identified the incompatibility of electronic devices with assistive technologies as another key barrier [23,27]. In addition to these technological constraints, several behavioural or attitudinal constraints impeding ICT usage among PwD have emerged from research. For example, existing studies have found that lack of interest, resistive attitude, privacy concerns and low motivation are key reasons for the non-usage and non-access of ICT among PwD [10,36,37]. Other behavioural factors

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Table 1
Variable descriptions and summary statistics.

Variables	Definition	Mean	SD
A. Output variable			
ICT_USE_HEALTH	A dummy variable indicating whether or not the respondent has used at least one type of ICT tools from the following in the last 3 months for health purposes. This includes use of Internet to access health services, disability specific mobile apps and Internet based health services particularly related with disability (1 = has used ICT enabled health services, 0 = otherwise)	0.07	0.25
B. Explanatory variable			
ICT_ACCESS	A dummy variable indicating whether or not the respondent has access at least one type of ICT devices including use of computer, mobile phone, tablets and Internet (1 = has access to ICT devices, 0 = otherwise)	0.49	0.50
C. Control variables			
HEALTH	A categorical variable indicating level of self-assessed health status (1 = poor, 2 = fair, 3 = good, 4 = very good, and 5 = excellent)	2.96	0.70
HEALTH_CARE_USE	A dummy variable indicating whether or not the respondent has received health care assistance from organised services (1 = has received health care assistance, 0 = otherwise)	0.08	0.27
HH_INCOME	A categorical variable indicating the quintile of the respondent's household income (1 = 1st quintile, 2 = 2nd quintile, 3 = 3rd quintile, 4 = 4th quintile, and 5 = 5th quintile)	2.19	0.85
AGE_REC	A categorical variable indicating the age group of the respondent (1 = 0–14 years, 2 = 15–29 years, 3 = 30–44 years, 4 = 45–59 years, 5 = above 60 years)	4.44	1.07
GENDER_REC	A dummy variable indicating the gender of the respondent (1 = male , 0 = female)	0.41	0.49
EDU_REC	A categorical variable indicating the respondent's highest level of educational attainment (1 = year 12 or below, 2 = certificate III or IV, 3 = advanced diploma, 4 = Bachelor, 5 = postgraduate)	1.41	0.93
EMPLOY_STATUS_REC	A dummy variable indicating the labour force status of the respondent (1 = employed , 0 = otherwise)	0.14	0.35
MARRITAL_STATUS	A dummy variable indicating whether or not the respondent is married or not (1 = married, 0 = otherwise).	0.32	0.47
COB_ENG	A dummy variable indicating whether or not a respondent originated from Australia or any other English speaking country (1 = yes, 0 = no)	0.84	0.37
DISBSTAT_REC	A categorical variable indicating the respondent's level of disability (1 = no limitation, 2 = mild, 3 = moderate, 4 = severe, 5 = profound)	3.69	1.50
REMOTENESS_REC	A dummy variable indicating whether or not a respondent person lives in a remote area (1 = resident of a remote area, 0 = major or inner regional city)	0.14	0.34
DISAB_SUP	A dummy variable indicating whether or not the respondent received disability support payment from the government (1 = yes, 0 = no)	0.07	0.26
D. Moderator variables			
TECH_CONST	Aspects of Information Technology (IT) or Electronic Technology (ET) (viz. no access, lack of digital skill, lack of affordability, poor service quality or lack of Assistive Technology (AT)) which can potentially impede Internet use, and thereby moderate the impact of ICT access on ICT use for health purposes (1 = a respondent reported not being able to use the Internet due to above mentioned IET aspects, 0 = otherwise)	0.07	0.25
BEHAV_CHARAC	Behavioural aspects or characteristics of PwD (viz. lack of trust, lack of time, needs support or lack of interest) which can potentially impede Internet use, and thereby moderate the impact of ICT access on ICT use for health purposes (1 = a respondent reported not being able to use the Internet due to behavioural aspects, 0 = otherwise)	0.16	0.37
Number of observations		23,343	

include a lack of support [2,8,10], and time constraints [37,43] as major barriers to technology adoption by PwD. It is evident from existing empirical research that both technological and behavioural factors impede the ICT usage among PwD.

Although the research cited above provides a number of valuable insights, significant gaps in our knowledge remain. Firstly, studies looking at the connection between disability and telehealth have basically reviewed articles related to consumer health informatics for PwD. The major limitation of these studies is that the conclusions drawn are subjective, thus reflecting the authors' judgment. Secondly, although we know that both technological and behavioural factors matter, there has been no systematic examination, and thus no scholarly consensus, on the relative impact of each factor [8,11]. To address these gaps, the current study poses two research questions: (i) What are the factors that explain ICT-enabled health care usage among PwD? (ii) Do technological or behavioural aspects moderate ICT-enabled health care usage most significantly? This article differs from previous studies in two major ways. First, to the best of the authors' knowledge, the current study is the first of its kind to investigate the determinants of ICT-enabled health care usage among PwD using a quantitative framework based on a comprehensive nationwide survey on disability. Second, this study compares the relative strength of the moderating effects of technological and behavioural aspects on ICT-enabled health care usage among PwD. This study provides a more reliable quantitative answer to the question of which factors matter and enables a broader understanding of the relative importance of each. Thus, it provides insight to policymakers and private actors in responding to the digital disability divide.

The paper proceeds in Section 2 by describing the data and methods, and presents and discusses the empirical results in Sections 3 and 4. Section 5 concludes by pointing to policy implications and discussing the limitations of the current study.

2. Materials and methods

2.1. Data source

The current study is based on the Australian Bureau of Statistics (ABS) Microdata – Basic Confidentialised Unit Record Files compiled through the 2015 Survey of Disability, Ageing and Carers (SDAC). The survey methodology is thoroughly explained in ABS [1]. The survey was conducted across all Australian states and territories and in all urban, rural and remote areas. Respondents are older people, carers, and PwD residing in private homes or establishments such as hospitals and aged care facilities. The final combined sample consisted of 75,211 individuals. The analysis presented in this study was based on the data originating from 23,343 individuals who identified themselves as being disabled.

2.2. Variables

Detailed information about people with disabilities, carers and older people along with a breakdown of key demographic variables and ICT-related information is reported in the 2015 SDAC. The current study uses demographic variables, such as age, gender, educational accomplishment, employment status and personal income. ICT-related information used in this study includes access to ICT tools (e.g. computer, mobile phone, tablets and the Internet) and the use of these tools for health care. To capture the financial situation of an individual beyond income and employment status, variables for disability support

payments and other benefits received from the government are also included. For some variables, such as household income and remoteness, data are reported at the household level in the SDAC. Information on these household level variables were then matched with the corresponding individual-level information using household and person identifiers. Following the existing literature [10,36,37], the current study presumes that technological constraints are present if an individual reports any of the following impediments to using Information Technology (IT) or Electronic Technology (ET) – (i) no access to ICT devices, (ii) lack of digital skill, (iii) lack of affordability, (iv) experienced poor quality of service, or (v) lack of Assistive Technology (AT). Guided by previous empirical studies [2,8,10], this study defines a PwD as impeded by behavioural aspects if that person reports being unable to use the internet due to any of the following: (i) lack of trust, (ii) lack of time, (iii) needs support, or (iv) lack of interest. Although other behavioural aspects could no doubt impede ICT usage, we use these characteristics based on definitions used in previous studies and the availability of data in the SDAC.

Table 1 provides the definitions of the variables included in the models along with their means and standard deviations. The classification of the variables also reflects the model specifications, as outlined in Section 2.3.1. The variables listed in Panel A are the outcome variables, those in Panel B are the explanatory variables and those in Panel C and D list control and moderating variables, respectively.

2.3. Model specification and estimation method

2.3.1. Model specification

The multivariate hierarchical regression model is deployed to predict the relationship between the dependent variable and the explanatory variables. This type of modelling is used to show whether the variables of interest can explain a statistically significant portion of variance in the dependent variable after accounting for all other variables. This framework builds several regression models by adding variables to a prior model at each step. The moderating effects of technological and behavioural characteristics and the control for confounding effects are performed following the stepwise procedure advocated by Jaccard et al. [21]. A seven-tier multivariate regression is employed as follows through seven steps: (1) Independent dimensions and potential confounders are introduced into the regression model. (2) The first moderator (i.e. technological characteristics) is introduced. (3) The second moderator (i.e. behavioural characteristics) is introduced. (4) Both moderators are included. (5) The interaction term for the first moderator (i.e. the product of ICT access and technological characteristics) is included. (6) The interaction term is introduced for the second moderator (i.e. the product of ICT access and behavioural characteristics). (7) Finally, interaction terms are introduced along with independent, control and moderator variables.

In accordance with the preceding discussion and existing literature, the following estimation equations are hypothesised:

$$ICT\_USE\_HEALTH = \beta_1 + \beta_2 ICT\_ACCESS + \Lambda X_{it} + \varepsilon_{it} \quad (1)$$

$$ICT\_USE\_HEALTH = \beta_1 + \beta_2 ICT\_ACCESS + \beta_3 IT\_ET\_ARTEFACTS + \Lambda X_{it} + \varepsilon_{it} \quad (2)$$

$$ICT\_USE\_HEALTH = \beta_1 + \beta_2 ICT\_ACCESS + \beta_4 BEHAV\_CHARAC + \Lambda X_{it} + \varepsilon_{it} \quad (3)$$

$$ICT\_USE\_HEALTH = \beta_1 + \beta_2 ICT\_ACCESS + \beta_3 IT\_ET\_ARTEFACTS + \beta_4 BEHAV\_CHARAC + \Lambda X_{it} + \varepsilon_{it} \quad (4)$$

$$ICT\_USE\_HEALTH = \beta_1 + \beta_2 ICT\_ACCESS + IT\_ET\_ARTEFACTS + \beta_4 BEHAV\_CHARAC + \beta_5 ICT\_ACCESS \times IT\_ET\_ARTEFACTS + \Lambda X_{it} + \varepsilon_{it} \quad (5)$$

$$ICT\_USE\_HEALTH = \beta_1 + \beta_2 ICT\_ACCESS + \beta_3 IT\_ET\_ARTEFACTS + \beta_4 BEHAV\_CHARAC + \beta_5 BEHAV\_CHARAC \times IT\_ET\_ARTEFACTS + \Lambda X_{it} + \varepsilon_{it} \quad (6)$$

$$ICT\_USE\_HEALTH = \beta_1 + \beta_2 ICT\_ACCESS + \beta_3 IT\_ET\_ARTEFACTS + \beta_4 BEHAV\_CHARAC + \beta_5 ICT\_ACCESS \times IT\_ET\_ARTEFACTS + \beta_6 BEHAV\_CHARAC \times IT\_ET\_ARTEFACTS + \Lambda X_{it} + \varepsilon_{it} \quad (7)$$

ε_{it} is the error term. β_1, β_2, β_3, β_4, β_5, β_6 and the vector Λ are the parameters to be estimated.

2.3.2. Estimation method

Multivariate logistic regression was conducted using Stata 15 package for the baseline (Model 4) and interaction effect (Model 7) estimations. For the independent variables included in the multivariate logistic regression model coefficients, odds ratios (OR) and 95% confidence intervals (95% CI) were calculated. After adjusting for standardised weights from the 23,343 cases, the multivariate logistic regression models of ICT-enabled health service usage were estimated. In addition, the independent variables (ICT access) were centred to obtain a meaningful result from the interaction effects. The addition of an interaction effect to a model may render the main effect of that model uninteresting [41]. To overcome this limitation, the explanatory variable was centred by subtracting the mean from each case, then computing the interaction term and estimating the model [41]. Robustness checks using multivariate probit estimations for baseline and interaction effect estimations were also conducted.

2.3.3. Diagnostic tests and measures of fit

Multivariate logistic regression modelling was followed by multicollinearity diagnostic analysis with estimations of variance inflation factor (VIF) values for independent variables. In addition, to measure the overall goodness-of-fit, a Homer and Lemeshow test and Chi-square test were conducted for each regression model. Moreover, several scalar measures of fit, including such as Nagelkerke R-squared, Bayesian Information Criterion (BIC) and Bayesian Information Criterion prime (BIC′), were also estimated to make a comparative assessment of the appropriateness of several hypothesised models.

3. Results

3.1. Sample characteristics

Exploratory data analysis offers a broad initial view of the sociodemographic characteristics of the respondents. Thus, summary statistics of the variables used in the study and the characteristics of the study group are presented in Tables A2 and A3, respectively. Across the sample, the proportion of women (58.59%) is generally greater than that of men (41.41%), and approximately 72.00% are aged above 60 years. More than three-quarters (79.00%) has an education level equivalent of year 12 or below. A large majority (85.77%) are either unemployed or not in the labour market. Approximately one-third of the respondents (32.38%) are married. More respondents are from English-speaking origins (including Australia) (89.93%) than non-English-speaking counterparts (16.07%). Almost half of the total respondents (48.86%) have profound impairment. As for the place of residence, a significant proportion (28.00%) live in major or inner regional cities.

Around half of the total respondents (51.00%) have no ICT access, whereas the rest (49.00%) has some level of access. Interestingly, 6.69% of respondents have not been able to use Internet due to technological constraints. Meanwhile, 16.39% of respondents cannot use the Internet due to behavioural constraints or characteristics. These numbers are partly corroborated by the high prevalence of PwD with severe and profound impairment. Altogether, these simple cross-

tabulations point to a moderate level of adoption of ICT in general among PwD.

3.2. Baseline estimations

At the succeeding step, multivariate logistic regression models were estimated to predict the usage of ICT-enabled health care depending upon several predictors, including ICT access, two different moderating variables and several other socio-demographic and locational variables as control variables. Seven stepwise models were generated from the baseline model (Model 1) to a comprehensive model with interactions of two sets of moderators (Model 7). Given the limitations of space, only the results for Model 4 and Model 7 are discussed here.

As expected, those who report having ICT access are much more likely (12.64 times; 95% CI: 9.24–17.27, p = 0.000) to use ICT-enabled health care than those who report no ICT access (Table 2). Self-assessed health status is also a strong predictor of ICT-enabled health care usage (Table A2). The odds of ICT-enabled health care usage is slightly less pronounced for PwD with very good (OR: 0.57; 95% CI: 0.44–0.73, p = 0.000) and excellent health status (OR: 0.52; 95% CI: 0.37–0.72, p = 0.000) compared with those with poor health status. The likelihood of using health care from organised care increases the odds of using ICT-enabled health care by 33% (95% CI: 1.10–1.60, p = 0.003). Meanwhile, the probability of the ICT-enabled health care usage of the respondents belonging from the highest quintile household income is 1.30 times (95% CI: 1.01–1.67, p = 0.043) compared to those in the lowest household income quintile. The odds of using ICT-enabled health care decreases as the age cohort increases, especially for people aged 60 and older. For people aged 30–44 years, the chance of using ICT-enabled health care is 2.56 times (95% CI: 1.78–3.69), p = 0.000) higher than people aged under 15. For those aged 45–59 years, this chance is 1.51 times (95% CI: 1.05–2.17, p = 0.027) higher. Interestingly, the odds of using ICT-enabled health care is 18% lower among male respondents than their female counterparts (Table A1). Therefore, the well–documented health care utilisation gap in favour of women [5,40] in this case appears to outweigh the ICT utilisation gap in favour of men [24].

The likelihood of using ICT–enabled health care increases with the level of educational attainment (Table 2). People who have Certificate III or IV are 1.24 times (95% CI: 1.05–1.46, p = 0.009) more likely to use ICT–enabled health care than those who have an education level of year 12 or below. For those who have an advanced diploma, bachelor and postgraduate or higher degree, the odds of using ICT-enabled health care are respectively 1.91 (95% CI: 1.57–2.34, p = 0.000), 2.33 (95% CI: 1.93–2.80, p = 0.000) and 2.76 (95% CI: 2.20–3.45, p = 0.000) times higher than the group with lowest level of education (Table 2). The odds of using ICT-enabled health care is 39% higher (95% CI: 1.20–1.62, p = 0.000) among the employed than the odds of those without jobs or unavailable for work (Table 2). The chance of using ICT-enabled health care is 51% higher (95% CI: 1.17–1.94, p = 0.001) for people who have reported profound impairment than for those without any limitation due to disability. However, no statistically significant differences are found between those who reported having mild impairment and no limitation (OR: 1.07; 95% CI: 0.91–1.25, p = 0.417) and between those PwD who reported having severe impairment and no limitation (OR: 1.12; 95% CI: 0.91–1.38, p = 0.283).

The odds of using ICT-enabled health care are 45% higher (95% CI: 1.20–1.75, p = 0.000) among PwD originating from English-speaking origins than PwD from other countries (Table 2). ICT-enabled health service adoption in remote areas among PwD are 17% less (95% CI 0.70–0.99, p = 0.000) than those living in cities (Table 2). No statistically significant differences between recipients of disability support payment (OR: 1.17; 95% CI 0.97–1.42, p = 0.107) and non-recipients in the usage of ICT-enabled health care.

3.2.1. Moderation effect

From the baseline model with direct effects (Model 4), the odds of using ICT-enabled health care among PwD reduce by 27% (95% CI 0.10–0.76, p = 0.013) when the respondent reports access limitations we have included as technological constraints. Meanwhile, the odds of using ICT-enabled health care among PwD reduces by only 2% (95% CI 0.01–0.04, p = 0.000) when respondents report barriers we have listed under behavioural characteristics (Table 2).

The stepwise estimations with moderated effects (Model 7) demonstrate the impact of this moderation effect on the nexus between ICT-enabled health service usage and ICT access. As shown in Table A3 (Model 7), the responsiveness of ICT access on ICT-enabled health service usage is predicted to fall by 1.08 units in the presence of reported technological constraints. In other words, as shown in Table 3, the effect of ICT access on ICT-enabled health care utilisation falls by 34% when the respondent reports some technological constraint (95% CI 0.03–4.42, p = 0.014). Meanwhile, the responsiveness of ICT access on ICT-enabled health service usage is predicted to fall by 5.02 units in the presence of non-accommodative behavioural characteristics (Table A3), a decrease of 1% (95% CI: 0.00–0.04, p = 0.000) (Table 3). The Wald test indicates that the difference between the interaction effects of two moderators (33%) is statistically significant (Chi-squared = 4.91, p = 0.027). Therefore, it can be concluded that the detrimental impact of technological constraints on ICT-enabled health care usage is much greater than that of behavioural constraints when respondents have access to ICT devices. These kinds of interaction effects do not necessarily reflect large differences in practice. However, these two sets of factors moderate the impact of ICT access on ICT-enabled health care use. As a result, the effect of technological constraints on ICT-enabled health care is amplified.

3.2.2. Diagnostics tests and measures of fit

A multicollinearity diagnostics analysis was followed by multivariate logistic regression modelling with a calculation of VIF values for independent variables across all stepwise regression models. No concerns are raised here, since all mean VIF values for Model 4 and Model 7 are below 4.0 (see Table A4). Model 4 and Model 7 reveal adequate overall goodness-of-fit as indicated by the Homer and Lemeshow Chi-square tests (Model 4: Hosmer and Lemeshow test Chi-squared = 14.28, df = 8, p = 0.107; Model 7: Hosmer and Lemeshow test Chi-squared = 6.29, df = 8, p = 0.391).

Pseudo R-squared value for the regression without moderation effects (Model 4) is 0.267, whereas that for the model with both sets of moderation effects (Model 7) is 0.270 (see Tables A2 and A3). The strength of the interaction effect is 0.03. In other words, both interaction effects account for 3% variation in the likelihood of using ICT-enabled health care. This result supports for Model 7 with interaction effects. In addition, scalar measures of fit, namely, Nagelkerke R-squared, BIC and BIC′, also reveal strong support for Model 7 (moderation effects) over other models, namely, Model 4 (direct effects), Model 5 and Model 6 (see Table A5). In particular, the difference of 21.49 in BIC' between Model 4 and Model 7 provides strong support for the current model (Model 7).

3.3. Robustness checks

Robustness checks using multivariate probit regression corroborate the findings of the baseline estimations (Table A6). ICT-enabled health service adoption among PwD is dependent on self-assessed health status, health care use from organised service, personal income, age category, gender, level of education, marital status, employment status,

Table 2
Multivariate hierarchical logistic regression model examining predictors influencing ICT enabled health service use among PwD (direct effects).

Variable	Step 1				Step 2				Step 3				Step 4			
	OR	p	95% CI		OR	p	95% CI		OR	p	95% CI		OR	p	95% CI	
ICT_ACCESS																
- no/yes	5.73*	0.000	4.31	7.63	7.15*	0.000	5.34	9.58	12.29*	0.000	9.00	16.78	12.64*	0.000	9.24	17.27
HEALTH																
- poor																
- fair	0.88	0.266	0.70	1.10	0.83	0.112	0.66	1.04	0.80***	0.067	0.63	1.02	0.80***	0.064	0.63	1.01
- good	0.69*	0.001	0.56	0.86	0.66*	0.000	0.53	0.82	0.62*	0.000	0.49	0.77	0.62*	0.000	0.49	0.77
- very good	0.67*	0.001	0.52	0.85	0.62*	0.000	0.49	0.79	0.57*	0.000	0.44	0.73	0.57*	0.000	0.44	0.73
- excellent	0.59*	0.002	0.43	0.82	0.55*	0.000	0.40	0.77	0.52*	0.000	0.37	0.72	0.52*	0.000	0.37	0.72
HEALTH_CARE_USE																
no/yes	1.17***	0.080	0.98	1.40	1.22**	0.034	1.02	1.46	1.31*	0.004	1.09	1.58	1.33*	0.003	1.10	1.60
HH_INCOME																
- Quintile 1																
- Quintile 2	1.05	0.612	0.87	1.26	0.99	0.928	0.82	1.19	0.91	0.328	0.75	1.10	0.91	0.310	0.75	1.10
- Quintile 3	1.29**	0.021	1.04	1.61	1.20	0.105	0.96	1.49	1.08	0.490	0.87	1.35	1.08	0.517	0.86	1.35
- Quintile 4	1.21	0.121	0.95	1.53	1.13	0.314	0.89	1.44	1.02	0.869	0.80	1.30	1.02	0.903	0.80	1.29
- Quintile 5	1.54*	0.001	1.20	1.97	1.44*	0.004	1.12	1.85	1.30**	0.042	1.01	1.67	1.30**	0.043	1.01	1.67
AGE_REC																
- 0–14 years																
- 15–29 years	1.67*	0.005	1.16	2.40	1.74*	0.003	1.21	2.49	2.02*	0.000	1.41	2.90	2.02*	0.000	1.41	2.91
- 30–44 years	1.88*	0.001	1.31	2.68	2.05*	0.000	1.43	2.94	2.54*	0.000	1.77	3.65	2.56*	0.000	1.78	3.69
- 45–59 years	1.00	0.997	0.70	1.43	1.14	0.489	0.79	1.63	1.49**	0.031	1.04	2.15	1.51**	0.027	1.05	2.17
- 60 years and above	0.54*	0.000	0.38	0.76	0.66**	0.020	0.47	0.94	1.08	0.688	0.76	1.53	1.09	0.616	0.77	1.56
GENDER_REC																
- female/male	0.80*	0.000	0.71	0.90	0.80*	0.000	0.72	0.90	0.82*	0.001	0.73	0.92	0.82*	0.001	0.73	0.92
EDU_REC																
- year 12 or below																
- certificate III or IV	1.46*	0.000	1.24	1.72	1.41*	0.000	1.20	1.65	1.25*	0.008	1.06	1.47	1.24*	0.009	1.05	1.46
- advance diploma	2.53*	0.000	2.07	3.08	2.35*	0.000	1.93	2.87	1.93*	0.000	1.58	2.36	1.91*	0.000	1.57	2.34
- bachelor	3.06*	0.000	2.54	3.68	2.83*	0.000	2.35	3.40	2.35*	0.000	1.95	2.83	2.33*	0.000	1.93	2.80
- postgrad or higher	3.96*	0.000	3.16	4.96	3.55*	0.000	2.84	4.45	2.79*	0.000	2.22	3.49	2.76*	0.000	2.20	3.45
EMPLOY_STATUS_REC																
- otherwise/employed	1.55*	0.000	1.33	1.80	1.51*	0.000	1.29	1.75	1.39*	0.000	1.20	1.61	1.39*	0.000	1.20	1.62
MARRITAL_STATUS																
- otherwise/married	1.25*	0.001	1.09	1.42	1.21*	0.005	1.06	1.38	1.18**	0.016	1.03	1.35	1.18*	0.016	1.03	1.35
COB_ENG																
- no/yes	1.67*	0.000	1.39	2.01	1.60*	0.000	1.33	1.93	1.46*	0.000	1.21	1.76	1.45*	0.000	1.20	1.75
DISBSTAT_REC																
- no limitation																
- mild	1.09	0.314	0.93	1.27	1.06*	0.443	0.91	1.25	1.07	0.398	0.91	1.26	1.07	0.417	0.91	1.25
- moderate	1.22**	0.042	1.01	1.49	1.22**	0.050	1.00	1.48	1.18***	0.099	0.97	1.44	1.18	0.104	0.97	1.43
- severe	1.10	0.365	0.90	1.35	1.08	0.466	0.88	1.33	1.12	0.289	0.91	1.38	1.12	0.283	0.91	1.38
- profound	1.21	0.123	0.95	1.53	1.26***	0.059	0.99	1.61	1.49*	0.002	1.16	1.91	1.51*	0.001	1.17	1.94
REMOTENESS_REC																
- city/remote area	0.79*	0.006	0.67	0.94	0.81**	0.013	0.68	0.96	0.83**	0.036	0.70	0.99	0.83**	0.037	0.70	0.99
DISAB_SUP																
- no/yes	1.15	0.131	0.96	1.39	1.23**	0.033	1.02	1.48	1.17	0.104	0.97	1.42	1.17	0.106	0.97	1.42
TECH_CONST																
- no/yes					0.03*	0.000	0.01	0.07					0.27**	0.013	0.10	0.76
BEHAV_CHARAC																
- no/yes									0.01*	0.000	0.01	0.03	0.02*	0.000	0.01	0.04
Constant	0.01*	0.000	0.01	0.02	0.01*	0.000	0.01	0.02	0.01*	0.000	0.00	0.01	0.01*	0.000	0.00	0.01
Pseudo R-squared	0.221				0.239				0.275				0.276			
N	23,343				23,343				23,343				23,343			

Note: *, ** and *** denotes statistically significant at 1%, 5% and 10%, respectively.

degree of disability and place of residence. Similar to the baseline moderation effects regression (Model 7), multivariate probit regression also indicates that the negative impact of a technological characteristics moderator on the usage of ICT-enabled health care is much greater than that of behavioural constraints.

4. Discussion

This study investigates the determinants of the digital disability divide in the utilisation of health care services. As per the findings of the study, the young, the high-income and the educated are more likely to make use of ICT-enabled health services. This result accords with the findings of previous studies [16,26,35]. However, existing studies have investigated the relationship between the aforementioned

Table 3
Multivariate hierarchical logistic regression model examining predictors influencing ICT enabled health service use among PwD (moderated effects).

Variable	Step 5				Step 6				Step 7			
	OR	p	95% CI		OR	p	95% CI		OR	p	95% CI	
ICT_ACCESS												
- no/yes	7.29*	0.000	5.44	9.78	13.45*	0.000	9.83	18.42	13.86*	0.000	10.12	19.00
HEALTH												
- poor												
- fair	0.83	0.112	0.66	1.04	0.80***	0.068	0.63	1.02	0.80***	0.065	0.63	1.01
- good	0.66*	0.000	0.53	0.82	0.62*	0.000	0.49	0.78	0.62*	0.000	0.49	0.78
- very good	0.62*	0.000	0.49	0.79	0.57*	0.000	0.44	0.73	0.57*	0.000	0.44	0.73
- excellent	0.55*	0.000	0.40	0.77	0.52*	0.000	0.37	0.72	0.52*	0.000	0.37	0.72
HEALTH_CARE_USE												
- no/yes	1.21**	0.037	1.01	1.45	1.30*	0.006	1.08	1.56	1.31*	0.004	1.09	1.58
HH_INCOME												
- Quintile 1												
- Quintile 2	0.99	0.943	0.83	1.20	0.92	0.360	0.76	1.11	0.91	0.339	0.75	1.10
- Quintile 3	1.20	0.104	0.96	1.50	1.08	0.500	0.86	1.35	1.07	0.529	0.86	1.34
- Quintile 4	1.13	0.312	0.89	1.44	1.02	0.864	0.80	1.30	1.02	0.901	0.80	1.29
- Quintile 5	1.44*	0.004	1.12	1.85	1.30**	0.041	1.01	1.67	1.30**	0.043	1.01	1.67
AGE_REC												
- 0–14 years												
- 15–29 years	1.74*	0.003	1.21	2.49	2.03*	0.000	1.41	2.91	2.04*	0.000	1.42	2.92
- 30–44 years	2.05*	0.000	1.43	2.94	2.57*	0.000	1.79	3.70	2.60*	0.000	1.81	3.74
- 45–59 years	1.14	0.480	0.79	1.63	1.52**	0.025	1.06	2.19	1.54**	0.021	1.07	2.21
- 60 years and above	0.67**	0.022	0.47	0.94	1.10	0.582	0.78	1.57	1.13	0.511	0.79	1.60
GENDER_REC												
- female/male	0.80*	0.000	0.71	0.90	0.82*	0.001	0.73	0.92	0.81*	0.001	0.72	0.92
EDU_REC												
- year 12 or below												
- certificate III or IV	1.40*	0.000	1.19	1.65	1.24*	0.010	1.05	1.46	1.24*	0.011	1.05	1.46
- advance diploma	2.35*	0.000	1.93	2.86	1.92*	0.000	1.57	2.34	1.90*	0.000	1.55	2.32
- bachelor	2.82*	0.000	2.35	3.40	2.33*	0.000	1.94	2.81	2.31*	0.000	1.92	2.78
- postgrad or higher	3.55*	0.000	2.83	4.44	2.76*	0.000	2.20	3.46	2.73*	0.000	2.18	3.42
EMPLOY_STATUS_REC												
- otherwise/employed	1.51*	0.000	1.29	1.75	1.39*	0.000	1.20	1.61	1.39*	0.000	1.20	1.62
MARRITAL_STATUS												
- otherwise/married	1.21*	0.005	1.06	1.38	1.17**	0.021	1.02	1.34	1.17**	0.021	1.02	1.34
COB_ENG												
- no/yes	1.60*	0.000	1.33	1.93	1.46*	0.000	1.21	1.76	1.45*	0.000	1.20	1.75
DISBSTAT_REC												
- no limitation												
- mild	1.06	0.448	0.91	1.25	1.07	0.416	0.91	1.25	1.07	0.435	0.91	1.25
- moderate	1.22**	0.050	1.00	1.48	1.18***	0.099	0.97	1.44	1.18	0.105	0.97	1.43
- severe	1.08	0.460	0.88	1.33	1.13	0.260	0.92	1.39	1.13	0.253	0.92	1.39
- profound	1.27***	0.054	1.00	1.62	1.52*	0.001	1.18	1.95	1.55*	0.001	1.20	1.99
REMOTENESS_REC												
- city/remote area	0.81**	0.013	0.68	0.96	0.83**	0.034	0.70	0.99	0.83**	0.036	0.70	0.99
DISAB_SUP												
- no/yes	1.22**	0.036	1.01	1.48	1.15	0.149	0.95	1.40	1.15	0.152	0.95	1.40
TECH_CONST												
- no/yes	0.66**	0.048	0.62	0.75					0.70**	0.047	0.67	0.78
BEHAV_CHARAC												
- no/yes					0.16	0.908	0.38	2.96	0.19**	0.050	0.12	0.22
TECH_CONST × ICT_PENETRATION												
- no/yes	0.03*	0.003	0.00	0.32					0.34**	0.014	0.30	0.40
BEHAV_CHARAC × ICT_PENETRATION												
- no/yes					0.01*	0.000	0.00	0.03	0.01*	0.000	0.00	0.04
Constant	0.01*	0.000	0.01	0.02	0.01*	0.000	0.00	0.01	0.01*	0.000	0.00	0.01
Pseudo R-squared	0.240				0.277				0.278			

sociodemographic factors and ICT adoption in general. The current study provides deep insights into the digital disability divide by focusing particularly on ICT adoption for health care purposes. This study also reports that ICT-enabled health care usage is lower among males than females. This result runs counter to previous findings that women are less likely to use the Internet in general [18,26,39]. However, the result is in line with findings that men are less likely to use health care services in general [30]. These outcomes are presumably driven by cultural factors, such as masculinity conventions and stereotypes of self-reliance among men [42]. These findings can also be partly explained by gender-based differences in health care needs [13,24,30]. In the present context, it appears that traditional male reluctance to make use

of health care services dominates traditional female reluctance to make use of ICT tools.

The current study also finds that the higher the level of language proficiency, the higher the odds of using ICT-enabled health care. On this basis, proficiency in a particular language eases the access and use of the content as the contents of ICT-enabled health care are developed in the local language. This finding accords with findings of existing literature in the field of digital disability divide [26]. In addition, the findings of the study also indicate that those in remote areas are less likely to use ICT-enabled health care despite presumably having great need for such care. This result is likely driven partly by the lack of ICT infrastructure and skills in remote areas and partly by broad patterns of disadvantage in regional Australia [3,4].

We find, consistent with previous work, that technological and behavioural constraints both impede the use of ICT-enabled health care usage. However, the current study shows that the relative strength of the two moderators is rather different. This is a novel finding not reported in previous work. The findings indicate that the technological constraints reduce ICT-enabled health care use by 25%. This claim is broadly consistent with previous empirical work focusing on such technological constraints [10,36,37]. On the other hand, attitudinal or behavioural constraints are reported to reduce such utilisation by only a much smaller amount (2%). This finding is congruent with that of similar existing literature which showed that attitudinal factors affect the ICT-enabled health care usage [2,8,10]. These findings are cross-validated by the results generated from the set of regressions used to explore the moderating impact of technological and behavioural characteristics. Here we find a similarly large gap (approximately one third versus 1%). On this basis, it appears that technological constraints are much more significant than behavioural ones.

The current study makes a couple of novel contributions. First, instead of investigating the determinants of ICT adoption among PwD [15,17,33], the current study explores the factors that explain the adoption of ICT-enabled health services. Unlike the previous studies [9,18,19,25], the current study uses a comprehensive nationwide survey on disability following a quantitative framework. Second, this study compares the extent of moderating effect of technological and behavioural aspects on ICT-enabled health service usage.

5. Conclusion

This study investigates the factors explaining ICT-enabled health care usage among PwD. The results show that age, gender, income, level of education, language proficiency and remoteness are significant predictors of ICT-enabled health care usage. The major new finding is that technological constraints have a much larger moderating effect than behavioural constraints on the use of ICT-enabled health care.

The findings of the study have several practical implications. Most obviously, it strengthens the case for tackling the digital disability divide by looking at the underlying technological and economic factors which impede ICT utilisation. Although our results confirm that both technological and behavioural constraints matter (and we further suggest that a comprehensive policy approach must consider both), the stronger effect of technological constraints suggests that policy should be directed to addressing these problems first. ICT can be of great benefit to PwD, but technological and economic constraints are a limiting factor in adoption. Improving access, for example, the expansion of high-speed broadband, would help in this regard. To promote ICT accessibility for PwD in particular, the National Disability Insurance Agency in Australia is developing its long-term ICT infrastructure [29]. In addition, by integrating market regulation and anti-discrimination approaches in relevant public procurement procedures and consumer protection laws, affordable high-speed broadband Internet can be delivered to PwD. Nonetheless, to enhance the digital ability among PwD, the government should initiate targeted training through collaboration with private and other non-government agencies. Furthermore, producers should integrate accessibility features in designing digital products and services to handle the lack of AT.

Another broad implication of the findings of the study is that ICT is complementary to traditional forms of health care. Individuals using ICT for health are those who also use other services. Moreover, those most in need as measured by health status and access to disability support pension are the ones most likely to use ICT for health. Furthermore, a gender divide exists in ICT-enabled health care usage. As men are particularly unlikely to use ICT for health, targeted government programs should be initiated to increase adoption among male users. Finally, ICT-enabled health care usage among PwD in remote areas can be promoted by providing targeted training and facilitating improved access to high-speed affordable Internet through the National Broadband Network (NBN). The NBN can provide access to a wide range of services for disabled Australians.

CRediT authorship contribution statement

Mohammad Afshar Ali: Conceptualisation, Methodology, Data analysis, Formal Analysis, and Writing - Original Draft. **Khorshed Alam:** Conceptualisation, Supervision, Writing- Reviewing & Editing. **Brad Taylor:** Conceptualisation, Supervision, Writing - Reviewing & Editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

See Tables A1–A6.

Table A1
Characteristics of the study group.

Variable	Freq.	%	Variable	Freq.	%
ICT_USE_HEALTH			EMPLOY_STATUS_REC		
- No	21,822	93.48	- otherwise	20,021	85.77
- Yes	1,521	6.52	- employed	3,322	14.23
ICT_ACCESS			MARRITAL_STATUS		
- No	11,903	51.00	- otherwise	15,784	67.62
- Yes	11,440	49.00	- married	7,559	32.38
HEALTH			COB_ENT		
- poor	1,100	4.71	- other	3,752	16.07
- fair	2,360	10.11	- Australia/ English speaking	19,591	83.93
- good	16,928	72.52	DISBSTAT_REC		
- very good	2,346	10.05	- no limitation	2,627	11.25
- excellent	609	2.61	- mild	4,415	18.91
HEALTH_CARE_USE			- moderate	1,951	8.36
- otherwise	21,471	91.98	- severe	2,944	12.61
received service from organisation	1,872	8.02	- profound	11,406	48.86
HH_INCOME			REMOTENESS_REC		
- Quintile 1	2,550	10.92	- major or inner regional city	20,142	86.29
- Quintile 2	16,904	72.42	- remote area	3,201	13.71
- Quintile 3	1,690	7.24	DISAB_SUP		
- Quintile 4	1,227	5.26	- otherwise	21,597	92.52
- Quintile 5	972	4.16	- received	1,746	7.48
AGE_REC			TECH_CONST		
- 0–14 years	970	4.16	- No	21,782	93.31
- 15–29 years	1,051	4.5	- Yes	1,561	6.69
- 30–44 years	1,570	6.73	BEHAV_CHARAC		
- 45–59 years	2,988	12.8	- No	19,518	83.61
- 60 years and above	16,764	71.82	- Yes	3,825	16.39
GENDER_REC					
- Female	13,676	58.59			
- Male	9,667	41.41			
EDU_REC					
- year 12 and below	18,437	78.98			
- certificate III or IV	2,414	10.34			
- advance diploma	905	3.88			
- bachelor	1,032	4.42			
- postgrad or higher	555	2.38			

Table A2
Multivariate hierarchical logistic regression model examining predictors influencing ICT enabled health service use among PwD (direct effects).

Variable	Step 1		Step 2		Step 3		Step 4	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
ICT_ACCESS	1.84*	0.13	2.04*	0.13	2.50*	0.14	2.51*	0.14
HEALTH	−0.17*	0.03	−0.18*	0.03	−0.19*	0.03	−0.19*	0.03
HEALTH_CARE_USE	0.12	0.09	0.17***	0.09	0.25*	0.09	0.26*	0.09
HH_INCOME	0.09*	0.03	0.08*	0.03	0.06**	0.03	0.06**	0.03
AGE_REC	−0.31*	0.03	−0.26*	0.03	−0.15*	0.03	−0.15*	0.03
GENDER_REC	−0.29*	0.06	−0.29*	0.06	−0.26*	0.06	−0.27*	0.06
EDU_REC	0.39*	0.02	0.37*	0.02	0.30*	0.02	0.30*	0.02
EMPLOY_STATUS_REC	0.69*	0.07	0.65*	0.07	0.52*	0.07	0.52*	0.07
MARRITAL_STATUS	0.27*	0.07	0.23*	0.07	0.19*	0.07	0.19*	0.07
COB_ENG	0.51*	0.09	0.46*	0.09	0.36*	0.10	0.35*	0.10
DISBSTAT_REC	0.02	0.03	0.03	0.03	0.05***	0.03	0.05**	0.03
REMOTENESS_REC	−0.24*	0.08	−0.22*	0.08	−0.19**	0.09	−0.19**	0.09
DISAB_SUP	0.38*	0.09	0.43*	0.09	0.38*	0.09	0.38*	0.09
TECH_CONST			−3.59*	0.50			−1.29**	0.52
BEHAV_CHARAC					−4.28*	0.38	−3.95*	0.39
Constant	−3.92*	0.26	−4.03*	0.26	−4.39*	0.27	−4.41*	0.27
LR Chi-squared	2387.44*		2598.55*		3002.69*		3011.27	
Log-likelihood	−4430.36		−4324.80		−4122.73		−4118.44	
Pseudo R-squared	0.212		0.231		0.267		0.267	
N	23,343		23,343		23,343		23,343	

Note: *, ** and *** denotes statistically significant at 1%, 5% and 10%, respectively.

Table A3
Multivariate hierarchical logistic regression model examining predictors influencing ICT enabled health service use among PwD (moderated effects).

Variable	Step 5		Step 6		Step 7	
	Coef.	SE	Coef.	SE	Coef.	SE
ICT_ACCESS	2.05*	0.13	2.57*	0.14	2.59*	0.14
HEALTH	−0.18*	0.03	−0.19*	0.03	−0.19*	0.03
HEALTH_CARE_USE	0.17***	0.09	0.24**	0.09	0.25*	0.09
HH_INCOME	0.08*	0.03	0.06**	0.03	0.06**	0.03
AGE_REC	−0.26*	0.03	−0.15*	0.03	−0.14*	0.03
GENDER_REC	−0.29*	0.06	−0.27*	0.06	−0.27*	0.06
EDU_REC	0.37*	0.02	0.30*	0.02	0.30*	0.02
EMPLOY_STATUS_REC	0.65*	0.07	0.52*	0.07	0.52*	0.07
MARRITAL_STATUS	0.23*	0.07	0.19*	0.07	0.19*	0.07
COB_ENG	0.46*	0.09	0.35*	0.10	0.35*	0.10
DISBSTAT_REC	0.03	0.03	0.06**	0.03	0.06**	0.03
REMOTENESS_REC	−0.22**	0.08	−0.19**	0.09	−0.19**	0.09
DISAB_SUP	0.43*	0.09	0.36*	0.09	0.36*	0.09
IT_ET_ARTEFACTS	−0.26**	1.02			−0.34**	1.16
BEHAV_CHARAC			−0.34***	0.52	−0.44***	0.59
IT_ET_ARTEFACTS × ICT_PENETRATION	−3.61*	1.17			−1.08**	1.31
BEHAV_CHARAC × ICT_PENETRATION			−5.28*	0.78	−5.02*	0.84
Constant	−4.05*	0.26	−4.48*	0.27	−4.49*	0.27
LR Chi-squared	2603.51*		3032.76*		3041.40*	
Log-likelihood	−4322.32		−4107.70		−4103.38	
Pseudo R-squared	0.232		0.270		0.270	
N	23,343		23,343			

Note: *, ** and *** denotes statistically significant at 1%, 5% and 10%, respectively.

Table A4
VIF and goodness-of-fit test.

Test/statistics		M1	M2	M3	M4	M5	M6	M7
VIF	Min	1.02	1.02	1.02	1.02	1.02	1.02	1.02
	Max	2.99	1.61	1.71	3.45	4.60	3.57	6.53
	Mean	1.45	1.23	1.26	1.53	1.68	1.55	2.50
Hosmer-Lemeshow test	Chi-square	8.08	8.24	19.79**	14.28	7.84	12.23	6.29
	df	8	8	8	8	8	8	8
	p-value	0.232	0.221	0.032	0.107	0.250	0.057	0.391

Note: *, ** and *** denotes statistically significant at 1%, 5% and 10%, respectively.

Table A5
Scalar measures of fit.

Scalar measures	M4	M5	M6	M7	M7-M4	M7-M5	M7-M6
McFadden's R-squared	0.27	0.23	0.27	0.27	0.00	0.04	0.00
McFadden's Adj R-squared	0.27	0.23	0.27	0.27	0.00	0.04	0.00
Cox-Snell R-squared	0.12	0.11	0.12	0.12	0.00	0.02	0.00
Nagelkerke R-squared	0.32	0.28	0.32	0.32	0.00	0.04	0.00
Efron's R-squared	0.16	0.14	0.16	0.16	0.00	0.02	0.00
Count R-squared	0.94	0.94	0.94	0.94	0.00	0.00	0.00
Adj Count R-squared	<0.01	<0.01	<0.00	<0.00	<0.00	−0.01	<0.00
AIC	0.35	0.37	0.35	0.35	0.00	−0.02	0.00
AIC*n	8268.88	8676.65	8247.39	8242.75	−26.13	−433.89	−4.64
BIC	−226387.31	−225979.54	−226397.32	−226408.80	−21.49	−429.26	−11.48
BIC'	−2860.40	−2452.64	−2870.42	−2881.89	−21.49	−429.26	−11.48

Table A6
Multivariate probit regression model examining predictors influencing ICT enabled health service use among PwD (direct and moderated effects).

Variable	Step 4		Step 7	
	Coef.	SE	Coef.	SE
ICT_ACCESS	0.70*	0.07	0.76*	0.07
HEALTH	−0.14*	0.01	−0.14*	0.01
HEALTH_CARE_USE	0.14*	0.05	0.13**	0.05
HH_INCOME	0.04*	0.02	0.04*	0.02
AGE_REC	−0.03*	0.00	−0.03*	0.00
GENDER_REC	−0.11*	0.03	−0.11*	0.03
EDU_REC	0.16*	0.01	0.16*	0.01
EMPLOY_STATUS_REC	0.27*	0.04	0.26*	0.04
MARRITAL_STATUS	0.08**	0.04	0.08**	0.04
COB_ENG	0.16*	0.05	0.15*	0.05
DISBSTAT_REC	0.05*	0.01	0.05**	0.01
REMOTENESS_REC	−0.11**	0.05	−0.11**	0.05
DISAB_SUP	0.15*	0.05	0.13*	0.05
IT_ET_ARTEFACTS	−0.40**	0.19	−0.16	0.45
BEHAV_CHARAC	−1.61*	0.13	−0.22	0.24
IT_ET_ARTEFACTS × ICT_PENETRATION			−0.28**	0.50
BEHAV_CHARAC × ICT_PENETRATION			−1.68*	0.30
Constant	−2.09	0.14	−2.16*	0.14
LR Chi-squared	3102.45*		3134.09*	
Log-likelihood	−4072.85		−4057.034	
Pseudo R-squared	0.276		0.279	
N	23,343		23,343	

Note: *, ** and *** denotes statistically significant at 1%, 5% and 10%, respectively.

Appendix B. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jbi.2020.103480.

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