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Use of electronic devices by people attending vision rehabilitation services in

Italy: a study based on the Device and Aids Registry (D.A.Re)

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Conflict of interest: Federico Bartolomei, Eliana Costanzo, Ruth E. Hogg, John G. Lawrenson, Elisabetta Falchini, Alessia Di Simone, Valentina Pastore, Chiara Mastrantuono, Giovanni Sato, Filippo Amore, Ilaria Biagini, Giovanni L. Ciaffoni, Mauro Tettamanti, and Gianni Virgili have nothing to disclose.

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Running title: Electronic devices use in Italian D.A.Re registry

Key-points:

- 1) The Italian Device and Aids Registry (D.A.Re.) collects individual data from several vision rehabilitation services in Italy and provides detailed and extensive information on both the users and the technology.
- 2) The use of low-vision electronic devices, smartphones and tablets, contributes to improved vision-related quality of life in people attending vision rehabilitation services, as assessed with the Instrumental Activity of Daily Living (IADL).
- 3) Smartphones and tablets are used across different users' group, regardless of the use of optical or electronic low-vision aids, as well as of age and employment status.

Abstract

Purpose: To investigate the characteristics of electronic device users, specifically smartphones and tablets, in the Device & Aids Register (D.A.Re), from several low-vision rehabilitation services in Italy.

Methods: We collected general and clinical information about ocular and systemic diseases, visual function, reading speed and Instrumental Activities of Daily Living (IADL) questionnaire score. Technological details of each optical and electronic device, (including screen size, touch-screen and OCR functions, text-to-speech function) were also collected.

Results: 1218 patients (752 females and 466 males) were included in our analysis, mean age **71.5 (±18.8)** years. Users of electronic aids (n.237) were slightly younger (67 vs 72 years, $p<0.001$) than non-users (n.981), had a worse reading speed (38 vs 65 words/minute), critical print size (43 vs 28 print size, $p<0.001$), poorer visual acuity (VA)(1.0 logMAR or less: 30% non-users vs 73% users, $p<0.001$) and more commonly visual field restriction within 10° (23% vs 14%, $p=0.001$). A similar proportion of users and non-users were retired (about 70%) and about 16-17% were employed. The use of portable electronic devices (5'' or less, $p<0.001$; 6'' to 18'' screen size, $p=0.017$) was associated with better IADL scores, and the use of stand devices with worse IADL score ($p<0.001$); Furthermore, using smartphones and tablets (193 subjects) was strongly associated with better IADL scores.

Conclusion: We found that using electronic devices, and especially smartphone and tablets, were associated with better vision-related quality of life in low-vision people attending rehabilitation services. While this association does not mean causality, these findings seemed robust to confounder adjustment.

1 **Introduction**

2 Vision impairment affects an estimated 285 million people worldwide, according to data
3 published over a decade ago (1) and these estimates are rising for several eye conditions
4 (<https://www.who.int/multi-media/details/world-report-on--vision-infographic-page-1>).

5 People affected by low-vision, experience difficulty in common near activities such as
6 reading or writing,(2, 3) and the use of low-vision aids (LVAs) (including optical, non-optical and
7 digital/electronic) could help these patients overcome the social, physical and psychological
8 limitations they face in daily activities.(2)

9 The use of optical LVAs and, more recently, the introduction of electronic alternatives, may
10 enhance the performance of low-vision patients in their distance and near tasks.(2). Common LVAs
11 include optical (e.g., hand magnifiers, stand magnifiers, and telescopes), non-optical (e.g., large
12 print books, reading stand, typoscopes, and sunglasses), and digital (e.g., closed-circuit television
13 [CCTV] and portable digital magnifiers) devices.(3, 4) These instruments are particularly useful for
14 near tasks such as reading, writing, repairing and cooking.(5)

15 Portable (hand-held) electronic vision enhancement systems (p-EVES) are electronic devices,
16 widely available, that represent additional aids that are specifically designed for patients with visual
17 impairment. In addition to specifically designed p-EVES, personal smartphones or tablets can be
18 used to perform low vision functions both Android and iOS devices come preloaded with various
19 features as standard and a plethora of applications (apps) are now available for download aimed at
20 low-vision users.

21 An interest has recently emerged in the evaluation of smartphone and tablet use in people
22 with vision impairment.(6) Interestingly, people defining themselves as severely sight impaired
23 reported the use of smartphones and tablet computers as frequently as people with low vision.(6)
24 The main facilitators for these devices were the text-to-speech function, the ability to enlarge text,
25 the large screen and the use of camera flashlight as a spotlight and reduced stigma. On the other

26 hand, the high cost, the lack of awareness of how useful these devices could be for people with
27 vision impairment, and not having considered using these systems, could be considered barriers for
28 the use of these devices.(6) Finally, smartphone and tablets are generally not provided freely to
29 people with low-vision, at least in Italy.

30 The widespread interest in this topic led us to collect clinical and personal data of patients
31 affected by low vision disability using low-vision devices in a specific national registry.(7) The
32 Device & Aids Register (D.A.Re), was created in 2019 by the National Institute for Device and
33 Technology Assessment (Istituto Nazionale Valutazione Ausili e Tecnologie, INVAT) to collect
34 individual data from several low-vision rehabilitation centres, many of which are part of the Italian
35 Union for the Blind and Visually Impaired (Unione Italiana Ciechi e Ipovedenti, UICI).(7)

36 The aim of this study is to investigate the characteristics of electronic device users,
37 specifically of users of smartphones and tablets, as well as the reported Instrumental Activity of
38 Daily Living (IADL) score and its associations with patients' characteristics in users and non-users
39 of these devices.

40

41 **Methods**

42 *Study population*

43 This multicentre study involves different low-vision services affiliated with the Italian
44 Union for the Blind and Visually Impaired, the study coordinator center was the University of
45 Florence. The study protocol was approved by the Ethics Committee of the Area Vasta Centro-
46 Careggi, Florence in May 2019.

47

48 *The Device & Aids Register*

49 The D.A.Re collects general information on all patients attending low-vision services, as
50 age, gender, occupational status, blind registration status, general knowledge and use of computers
51 and software, integrating with clinical information about ocular and systemic diseases, visual

52 symptoms, visual acuity, reading speed (measured binocularly at 20 cm with appropriate correction
53 by the Minnesota low vision reading [MNREAD] chart), critical print size (CPS) and type of visual
54 impairment and, in addition, several details about the use of LVAs, knowledge of Braille, numerous
55 details on type, brand and scope of use of low-vision devices in use (optical, electronic or others)
56 and Instrumental Activities of Daily Living (IADL) score. The D.A.Re registry also collects
57 technological details on each optical and, particularly, electronic device, including screen size,
58 touch-screen and Optical Character Recognition (OCR) functions, text-to-speech function, or other
59 specific functions for several different devices. The screen specification provided by manufacturers
60 is the diagonal length, generally reported in inches. Subjects were considered users of a given
61 devices only if this was reported at the time of the most recent clinical encounter. The Device &
62 Aids Register (D.A.Re) data were collected in an anonymous standardised fashion. The
63 characteristics of D.A.Re registry have been reported previously.(7)

64

65 *Instrumental Activities of Daily Living (IADL) score*

66 The IADL questionnaire is a validated method to measure the functional health and quality
67 of life, in different clinical situations.(8, 9) Previous evidences indicates that evaluation of these
68 measures helps to identify problems that require treatment or care.(10) The questionnaire consisted
69 of eight questions regarding daily activities such as telephone use, shopping, cooking,
70 housekeeping, laundry, use of public transport, responsibility for drug taking, financial
71 management; different levels of autonomy were obtained for each question. A low IADL score
72 indicates good autonomy.

73

74 *Data analysis*

75 In the current investigation, the severity of vision impairment was evaluated as a variable,
76 no data on the duration of the vision impairment has been considered. Another variable included in
77 the present analysis was the hearing impairment, as reported by the patient.

78 Tablets and smartphones were considered separately from special purpose p-EVES, as they
79 are general purpose devices.

80 A challenge when reporting real-world data, including on vision rehabilitation, is the
81 dynamic nature of the data. For example, people may report on their experience with using optical
82 devices only at their first vision rehabilitation encounter, then be prescribed electronic devices,
83 which will influence their assessment at the following visits. Furthermore, their vision can change
84 between two assessments, and even their health status may be different. A strategy to manage this
85 complexity is being developed. In the current study we will take a pragmatic approach and consider
86 ‘encounters’ as the unit of analysis of interest, while accounting for within-subject correlation
87 statistically using mixed models, with individuals as random effects. The number of patients with
88 follow-up is still small in D.A.Re, and the choice of analytic approach is unlikely to affect the
89 estimates significantly. Statistical analyses comparing different groups of LVAs users were
90 conducted with linear or logistic mixed models, accounting for within-subject correlation in
91 individuals with multiple encounters recorded. Both univariate and multivariate associations were
92 calculated and presented. All analyses were conducted using Stata 17.0 software (StataCorp,
93 College Station, TX).

94

95 **Results**

96 A total of 1218 patients (752 females and 466 males) were included in our analysis, mean
97 age 71.5 (± 18.8) years. In this population we found 981 non-users of electronic devices (80.5%) and
98 237 users (19.5%), meaning for electronic devices all available devices and not only smartphones
99 and tablet.

100 Considering the overall population, we found that 1025 out of 1218 patients (84.2%) were non-
101 users of smartphones and tablet and 193 out of 1218 patients (15.8%) used smartphones and tablet.

102

103 *Differences between users and non-users of electronic devices*

104 Table 1 compares the characteristics of 237 (19.5%) electronic device users in 1218
105 subjects. The comparison of 193 (15.8%) users of smartphone and tablets with non-users is also
106 shown, together with the comparison of 151 (64%) stand vs 86 (36%) portable electronic devices
107 users.

108 Users of electronic aids were slightly younger than non-users (66.6 vs 72.1 years, $p<0.001$),
109 had a worse MNREAD reading speed (42.4 vs 64.4 wpm, $p<0.001$) and CPS (44.2 vs 28.5,
110 $p<0.001$) and more commonly visual field restriction within 10° (27.1% of users vs 16.1% of non-
111 users, $p<0.001$). Consistently, 77.6% users vs. 35.4% non-users of electronic devices had a visual
112 acuity of 6/60 (1.0 logMAR) or less ($p<0.001$). Differences in employment status were non-
113 significant between users and non-users of electronic devices, with about 1 in 6 being employed.

114 Comparing 237 users of stand (151 patients) vs portable (86 patients) electronic devices, age
115 and sex were similar (see Table 1). The analysis of the users of portable devices showed better
116 values for reading performance (59 wpm for users vs 32.3 wpm for non-users) and for distance
117 visual acuity ($p<0.001$). Differences in employment status were statistically significant ($p=0.022$)
118 but small, with slightly more employed subjects for users of portable electronic devices.
119 Finally, there were differences between users and non-users of smartphones and tablets, whether
120 iOS or Android (193 subjects). Users were much younger (55 vs. 74 years, $p<0.001$), therefore less
121 likely to be retired ($p=0.006$), and had less male dominance ($p=0.003$). Moreover, visual acuity and
122 reading speed were slightly better in users compared to non-users of smartphones and tablets, but
123 differences were minor, all details were reported in the Table 1. Figure 1 presents the overlapping in
124 the use of optical devices, electronic devices, and smartphone/tablets as a Venn diagram.

125

126 *Association with IADL score in all subjects*

127 Table 2 presents univariate analyses and multivariate models 1 and 2 (excluding or including
128 hearing impairment). As expected, in univariate analyses we found older age (0.13 per 10 years,
129 $p<0.001$), better-seeing eye VA (0.67 per 1 logMAR, $p<0.001$) and field restriction within 10°

130 (1.12, $p < 0.001$) were associated with worse (higher) IADL score. Reported hearing impairment was
131 also strongly associated with IADL score (0.72, $p < 0.001$). Among non-visual variables, being
132 employed or a student was associated with better IADL than being retired (-0.96, $p < 0.001$).

133 All the previous coefficients were confirmed in multivariable analyses, as shown in Table 2,
134 with an attenuation of employment status subgroups, probably due to age-adjustment. We used
135 screen size to group electronic device type as 5'' or less (n.57), 6'' to 18'' (n.34, nearly all portable
136 devices) and 19'' or more (n.146, all stand devices). Compared to non-users of electronic devices,
137 we found the use of portable devices (5'' or less, $p < 0.001$; 6'' to 18'' screen size, $p = 0.017$) was
138 associated with better IADL score, and use of stand devices with worse IADL score ($p < 0.001$).
139 We also assessed the effect of using iOS or Android smartphones and tablets (190 subjects), they
140 were strongly associated with better IADL scores when compared with non-users, with large effects
141 also in multivariate analyses, and no difference between iOS and Android devices ($p = 0.783$ in
142 model 2).

143

144 **Discussion**

145 In this study, based on a large registry of vision rehabilitation in Italy (D.A.Re.), we found
146 that patients using electronic devices, and especially smartphone and tablets, report better vision-
147 related quality of life in. While this association does not mean causality, adjusting by age, severity
148 of vision impairment and employment status, among other variables, did not alter the consistency of
149 this finding, which supports the robustness of our findings.

150 Users of electronic devices had worse vision and MNREAD reading performance than non-
151 users and were slightly younger. Users of smartphone and tablets differed from non-users in that
152 they were more likely to be employed or in education and had a slightly better reading performance,
153 although the electronic device user group contained a greater number of individuals who were
154 severely sight impaired. This highlights the heterogeneity of individual characteristics and modality
155 of use of electronic devices by different people. For example, severely sight-impaired subjects used

156 stand electronic magnifiers and no portable magnifiers, but they also used more smartphones and
157 tablets, likely due to their ability to perform text-to-speech and object identification functions. In
158 other words, there was no apparent prevailing combination of use of optical devices, electronic
159 devices, and smartphones and tablets.

160 Once the effect of age, severity of vision impairment and employment status was accounted
161 for, users of portable electronic devices and even more so users of smartphones and tablets had a
162 better IADL score than non-users. A scoping review (11) found that smartphones are able to
163 provide several facilities for severely visually impaired people such as: apps to learn Braille;
164 alternative ways of keying on a smartphone in Braille; new navigation and obstacle detection
165 systems for people with visual impairment; systems to improve magnification; apps for making
166 calls easier, and monitoring health. The review concluded that there is a gap in the literature with
167 limited research exploring the soft technology aspects of smartphones and apps, with a need for
168 more training and learning support research. Moreover, insufficient information is available from
169 app manufacturers regarding their capabilities. Service user involvement is critical when designing
170 a new technology and this has not been addressed adequately in most research studies investigating
171 smartphone technologies, including training in their use.

172 Previous qualitative research supports our findings. Yeo et al. (4) reported satisfactory use of
173 smartphone devices by visually impaired people of different ages and diagnoses for tasks including
174 face recognition, television or movie watching, near reading (newspaper, book, menu, or labels on
175 medicine bottles), computer or smartphone watching, distance reading (distant signs or a clock), and
176 letter writing. Abraham et al (12) found that a significant number of people living with severe
177 vision impairment or blindness used smartphones; however, most users are unaware of its full
178 functionality and assistive capabilities, as shown during vision rehabilitation. A number of free apps
179 have proved useful in people with different levels of vision impairment across a range of needs,(13)
180 including remote orientation and mobility instruction.(14) Multidisciplinary group training in the
181 use of apps was shown to be beneficial in older people.(15, 16, 17)

182 In Italy, at this time, smartphones and tablets are not usually considered aids for visually
183 impaired people and are not reimbursed by the Italian public healthcare system, unlike optical and
184 electronic aids are provided freely to legally blind people. Since they are used by many blind and
185 low vision people in their daily life, in this study we wanted to compare their use to that of special
186 purpose electronic devices, which, in our database, include hardware devices (which may include
187 installed software) e.g. video magnifiers (portable and stand), braille display, ebook readers,
188 scanner/OCR devices.

189 An interesting aspect is that mobile technology (smartphone and tablet), are universally
190 designed and are currently used also by people with no visual impairment, overcoming the social
191 stigma of the visually impaired patient and improving the social impact. (18) This social aspect of
192 visual rehabilitation becomes increasingly important concerning not only the LVAs' choice but the
193 need to treat the visually impaired patient as a person and not as a disease to be treated, considering
194 several aspects of social daily life.(19)

195 A strength of our study is the multicentre data collection in different low-vision services
196 affiliated with the Italian Union for the Blind and Visually Impaired, using a standardised data
197 collection which has previously been validated.(7) Moreover, since vision impairment is a dynamic
198 condition, a pragmatic approach was adopted linking actual use of a given device at the moment of
199 the clinical encounter to IADL and reading performance.

200 Our study based on the D.A.Re registry did not include children under 18 year-old, thus its
201 applicability is limited to adults. Of interest, Gothwal et al(20) found that recruitment of children
202 into a randomised controlled trial on the use of tablet computers is feasible in an international
203 context.

204 In conclusion, we suggest that low-vision services should educate users to become users of
205 electronic devices, particularly smartphone and tablets, considering their capacity and needs.
206 Pragmatic randomised control trials should be conducted on the provision and training of apps for

207 smartphone and tablets, including qualitative or mixed method research on how to personalise this
208 intervention.

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Author contributions

Federico Bartolomei: conceptualization of the work, data acquisition, analysis and interpretation of the results, final approval. Eliana Costanzo: conceptualization of the work, data analysis and interpretation of the results, manuscript drafting and final approval. Mariacristina Parravano: data analysis and interpretation of results. Ruth E. Hogg: data analysis and interpretation of results, manuscript drafting. John G. Lawrenson: data analysis and interpretation of results, manuscript drafting. Elisabetta Falchini, Alessia Di Simone, Valentina Pastore, Chiara Mastrantuono, Giovanni Sato, Filippo Amore, Ilaria Biagini, Giovanni L. Ciaffoni: data acquisition and revision of manuscript. Mauro Tettamanti: draft revision. Gianni Virgili: conceptualization and design of the work, data analysis and interpretation of the results, manuscript drafting and final approval.

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