Visual Acuity Screening of Refugees and Immigrants with a Web-Based Digital Test: A Pilot Study

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ABSTRACT

Purpose: To screen visual acuity in two refugee camps in Greece and explore the feasibility of replicating these methods on a nationwide scale.
Methods: Visual acuity was assessed in all participants using web-based Democritus Digital Acuity & Reading Test (DDART). Furthermore, the immigrants responded to a structured questionnaire regarding their demographics and medical history.
Results: A total of 330 adult refugees and immigrants were recruited. A total of 47.3% of the patients had never undergone ophthalmological examination. A significant negative correlation was detected between age ($r = -0.207$, $p < 0.001$) and educational background ($r = -0.135$, $p = 0.014$), suggesting that younger immigrants who had attended compulsory education were more likely to have their eyes checked in their home country. A total of 6.97% of patients presented with impaired vision and were referred for further care. All remote DDART measurements presented no differences from the corresponding hospital-based data in the referred cases.
Conclusions: Visual acuity screening using DDART provides valuable information regarding the visual capacity of refugees. The study outcomes suggest that pilot methods can be replicated on a nationwide scale.
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Patients Consent Statement: The patients sign written consent form.

KEYWORDS

refugees; immigrants; visual acuity; DDART; screening

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INTRODUCTION

Since 2015, the European Union (EU) has faced a challenging migration crisis (1). Millions of immigrants and refugees arrived in several European countries during past years; while political unrest in the Middle East, Africa, and recently in Ukraine suggests that the migration crisis will be escalate in the near future. Greece is the far southeast border of Europe and, traditionally, all major illegal transit routes from the East cross the Greek borders, either at the Aegean Sea or at the Evros river (2). Despite the full implementation of the Operation Poseidon from Frontex with 24/7 Aegean Sea borders surveillance, currently Greece hosts around 120.000 illegal immigrants and refugees in special designed accommodation centers; the majority of them being Afghani, Syrian and Somali (1).

The aforementioned populations are considered vulnerable because they migrate from countries with constrained National Healthcare Systems (NHS) and require both medical screening and care provision. As a result, the Greek NHS faces increased pressure for primary care provision in several remote continental and island areas. Despite the remarkable efforts of the Greek NHS's medical and paramedical staff, the overall care provision of refugees and illegal immigrants is still considered as suboptimal, primarily due to lack of resources and poor collaboration with the several non-governmental organizations that operate at the remote refugee camps (1–4).

Among the fundamental screening examinations for the refugees and the illegal immigrants is the visual acuity (VA), since: a) it reflects potential ocular-related diseases and faults; among them, refractive errors and cataract, b) reflects the sight-threatening impact of systemic diseases like the diabetes mellitus and the systemic hypertension, c) is a direct index of the overall visual performance of the examinee. To our knowledge, no official or unofficial screening program for VA has been implemented for refugees and illegal immigrants in Greece.

Recently, our group developed and validated the Democritus Digital Acuity & Reading Test (DDART) (5–7) which has been accredited by the Hellenic Drug Association as a valid test for clinical and screening purposes, both in conventional and telemedical settings. DDART requires no specialized hardware, while its' multilingual interface and its' advanced features allow any trained operator to provide accurate VA measurements from any remote setting.

Within this context, primary objective of this study was to screen the visual acuity of refugees and illegal immigrants from two camps, both in continental and island Greece and explore the feasibility of a nationwide screening program for refugees' VA assessment based on DDART.

MATERIALS & METHODS

SETTING

This was a pilot, observational study. Protocol adhered to the tenets of the Helsinki Declaration and written informed consent was obtained by all participants. The Research Ethics Committee of Democritus University of Thrace (DUTH) approved the protocol. The study was conducted at the Refugee Accommodation Center in Kavala (RACK), Greece and at the Pre-Removal Detention Center (PROKEKA) in the island of Kos in Greece between January 2022 and April 2022. The official registration number of the study is NCT05209581.

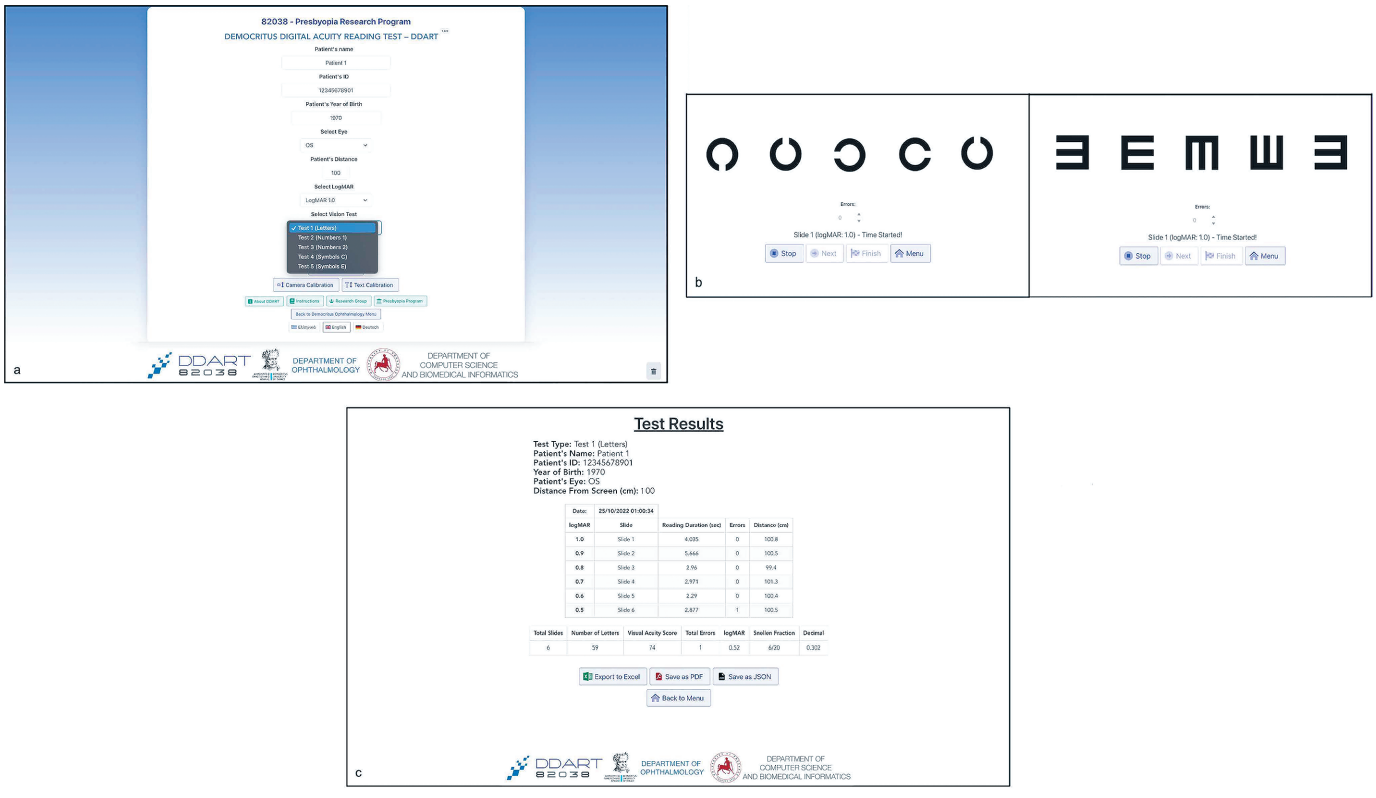

Fig. 1 VA measurement steps in DDART. a. Patient's Demographic Data, b. VA Testing, c. Result Page.

PARTICIPANTS

During participants' recruitment, RACK hosted a total of 400 adult refugees or immigrants originating primarily from Afghanistan and secondarily from Syria, Iran, Iraq, Somalia, Cameroon. PROKEKA hosted 130 adult immigrants originating from Palestine, Yemen, Pakistan, Iraq, Iran, Congo, Somalia, Ivory Coast, Cameroon, West Africa, Tongo, Lebanon, Sierra Leone, Angola, Bangladesh, Sudan and Mali.

Eligibility criteria included age over 18 years and refugee or immigrant status. Exclusion criteria included visual acuity lower than 1.0 logMAR (S.E. = 20/(20*(10^logMAR))), age under 18 years and refugees or immigrants living in the accommodation structures without having the appropriate legal documents.

DATA COLLECTION

Each participant responded to a structured questionnaire with the assistance of certified translators who were assigned by the administrative authorities of the RACK and the PROKEKA, respectively. The questionnaire pertained to the guest's demographics, medical and ophthalmological history. They were also asked if they have ever visited an ophthalmologist/optometrist. The original language of the questionnaire was English and was translated by the translator to each participant's native language.

Following the response to the questionnaire, visual acuity (VA) in each eye was assessed with the DDART(7), as described before, using the Landolt C or Thumbling E charts. For VA measurements we used a 55-inch smart-TV with a resolution of 3840 × 2160 pixels (4K) at a 3 meters distance. In order to assure reliable VA measurements, all researchers that used DDART addressed an online training course and received certification as DDART operators. The VA measurement steps using DDART are presented briefly in Figure 1.

Visual acuity assessment was performed in the same way and under the same conditions for all subjects. The examination was performed in specially designed rooms. The lighting conditions were the same for all subjects, which were verified using the portable Extech Lux Meter EA30 (Extech Instruments Corporation, USA). Examinees' distance from the chart was measured using a laser distance meter (Stanley TLM99s Laser Distance Measurer, Towson, Maryland, USA). The form of the chart used depends on the educational level of the examinee.

STATISTICAL ANALYSIS

A priori power analysis was performed. For an effect size of 0.3, 122 participants would be required for this study to achieve a power of 0.95 at the significance level of 0.05. The data were collected in MS Excel (Microsoft Corp.) and the statistical analysis was performed with Medcalc software version 20.0.0 for Windows (MedCalc Software, Mariakerke, Belgium).

Descriptive statistical analysis was performed. The Shapiro-Wilk test was used to evaluate the normality of the distribution of quantitative variables. In contrast, the chi-squared test was performed to assess and compare qualitative variables. Spearman's rank correlation coefficient was performed for the correlation between non-parametric variables. P values less than .05 were considered statistically significant.

RESULTS

A total of 330 adult refugees and immigrants (200 from the RACK and 130 from PROKEKA; 233 men, 97 women, aged 30 ± 11.5 years) participated in the study. The average VA of the examinees was 0 ± 0.2147 logMAR in the right eye and 0 ± 0.2098 logMAR in the left eye. The participant demographics and VA measurements are shown in Table 1.

Tab. 1 Study participants.

Parameters	Mean ± SD (Range)
Participants (n)	330 (233 men, 97 women)
Eyes (n)	660
Age (years)	30 ± 11.57 (23, 38)
Educational Background [% (n)]	
< Primary School	21.2% (70)
Primary School	32.1% (106)
Secondary School	36.1% (119)
College/University	10.3% (34)
Post Graduate	0.3% (1)
LogMAR right eye	0.0 ± 0.2147 (-0.1, 0.12)
LogMAR left eye	0.0 ± 0.2098 (-0.1, 0.2)

LogMAR = logarithm of the Minimum Angle of Resolution; SD = standard deviation

Participants who reported a diagnosis of eye disease or an optical fault accounted for 17.5% (58 of 330). Reports were primarily refractive errors, with the majority of them, myopia at a rate of 46.7% (28 out of 58) and presbyopia at a rate of 36.7% (22 out of 58). In total, 12.7% (42 of 330) used spectacles, while 4.2% (14 of 330) had been prescribed eye drops. Regarding former ophthalmological examinations, 47.3% (156 out of 330) of the participants had never visited an ophthalmologist/optometrist, while 30.9% (102 out of 330) had at least one ophthalmological

Tab. 2 Ophthalmological History.

Reported disease or fault	Participants (n)
Myopia	28 (46.7%)
Presbyopia	22 (36.7%)
Astigmatism	3 (5%)
Strabismus	3 (5%)
Dry eye	2 (3.3%)
Hyperopia	1 (1.7%)
Uveitis	1 (1.7%)
Last Ophthalmological Visit	
Never	156 (47.3%)
Last 3 years	102 (30.9%)
Last year	53 (16.1%)
Last month	19 (5.8%)

checkup during the past three years. A significant negative correlation was detected between age (r = −0.207, p<.001) and educational background (r = −0.135, p = .014), suggesting that younger immigrants who had attended compulsory education were more likely to have their eyes checked in their home country. However, no significant difference was detected between men and women in any of the parameters evaluated (Table 2).

World Health Organization suggests that VA values above 0.5 logMAR indicate moderate to severe visual impairment (8). 17 participants (5.16%) had VA above 0.5 logMAR. Moreover, 8 participants (2.43%) presented VA differences above 0.4 logMAR. In accordance to the above, study sample was divided into two groups. The first group included participants with normal vision (NVG) and the second group included participants who had either impaired visual acuity (moderate or severe) in at least one eye and / or significant difference in visual acuity between the two eyes (IVG). NVG participants were 93.03% of the sample, while the rest 6.97% populated the IVG (table 3).

Tab. 3 Comparison of groups.

	Group 1 % (n)	Group 2 % (n)
Visual acuity	Normal visual acuity 94.84% (313)	Impaired visual acuity 5.16% (17)
Difference of visual acuity	Difference < 0.4 97.57% (322)	Difference ≥ 0.4 2.43% (8)
Overall	Normal vision 93.03% (307)	Impaired vision 6.97% (23)

Difference = |LogMAR OD – LogMAR OS|

Considering the above data, a correlation was made between the 2nd group and the participants' frequency of visits to an ophthalmologist/optometrist. The analysis showed that out of a total of 23 participants in the group, six had never visited an ophthalmologist/optometrist. In the entire sample, they constituted 1.82%. At the same time, this percentage was correlated with educational background and sex. The results showed that participants with impaired visual acuity who had not visited an ophthalmologist/optometrist had completed primary or secondary school (3 primary school – 3 secondary school), while no clear superiority was found for gender (4 males – 2 females).

Regarding the examination procedure itself, all DDART operators reported no technical problems or other incidences in data collection, other than the case of 30-minute internet connection loss.

DISCUSSION

It is a truism that the medical care of refugees and immigrants is a challenge to the international community and especially to the hosting countries. Due to their compromised living conditions, they present increased healthcare needs (9, 10).

Unfortunately, the overall care provision at the EU refugee camps is still considered as suboptimal. In fact, the majority of care is covered by non-governmental organizations (NGO) (11–13). Despite the efforts of the volunteers of the NGOs and the generous funding from the European authorities, screening programs present questionable efficacy, primarily due to: a) inconsistency in clinical data collection, b) lack or questionable certification of the volunteers who act as clinical data-collectors, c) questionable processing of data the received. To avoid aforementioned inadequacies, we decided to implement a pilot study regarding VA screening in two camps in Greece and explore the potential feasibility to expand it to a nationwide or even European scale.

Within this context, the following prerequisites were addressed:

a) *Consistent data collection methods*. All VA measurements were obtained with the DDART, a high-end, web-based VA test which incorporates several digital enhancements; among them, biometric distance measurement, automatic measurement of the response time, automatic calculation of VA indexes, multilanguage interface that facilitate the examination process and improve consistency and reliability. DDART requires no specialized hardware, other than a high-resolution screen with a webcam and can be accessed from any remote camp with internet connection.
b) *Certification of the DDART operators who act as VA data collectors*. All local DDART operators received full training in DDART operation and the principles of VA examination. DDART certification program is a flexible, multilanguage online course that pertains to the general principles of VA examination, to the DDART's operation as a distance vision test, and to the DDART's operation as a near and intermediate distance vision test.
c) *Automatic calculation and statistical processing of VA measurements*. DDART automatically calculates all distance and near vision VA indexes, so there is no need of complex mathematical calculations from the operator. The VA report of each examinee is exported in pdf, xls and json digital formats. The latter format feeds a web-based database that allows real-time population statistical analysis. Moreover, each report can optionally be linked with the biometric photograph of the corresponding examinee to avoid misidentification.

Regarding the outcomes of present study, the average age of participants was 30 years old. 47.3% of them had never visited an ophthalmologist/optometrist, while 6,97% demonstrated impaired vision and were referred for a full ophthalmological examination and treatment in an ophthalmological department. In all referred cases, VA measurements at the hospital presented no significant differences with the corresponding ones that were received with the DDART. Significant negative correlation was detected between the probability of presenting impaired vision and frequency of former ophthalmological examinations in their home country. The most important of this study was the 1.82% of the whole sample, which had impaired vision and they had never visited an ophthalmologist/optometrist. This proves that 2 out of 100 in this population had unknown impaired vision. This fact demonstrates the increased eye care needs of the refugees.

To our knowledge, this is the first screening study for visual acuity in Greek refugee camps. Relevant literature revealed the following: Yameen et al. study with Syrian participants, reported an average age of 36 years and impaired visual acuity in 19.4% of the sample, which is higher than our 6.97%. In both studies, the most commonly found ocular disorders were the refractive errors (14). Ahmed et al. cohort study in Bangladesh with 68,462 Afghani refugees reported 7.7% visual impairment which is quite similar to our report (15,16). Kaphle et al. screening initiative in Malawi with 635 participants reported a 3.6% of vision impairment. Another interesting finding in Malawi study was that 95% of the participants had never visited an ophthalmologist/optometrist before (17).

Certain limitation of this study was the significant difference regarding the gender of the participants. Furthermore, in this study recruited immigrants from many different countries. Therefore, no definite conclusion can be drawn regarding the eye care needs of the individual origins. The population of Greek immigrant camps changes really fast, so it is difficult to perform an ophthalmic screening based on the origin of the refugees.

CONCLUSION

In conclusion, remote VA screening in Greek refugee and immigrant camps with DDART provided valuable information on the visual acuity of the participants and allowed the prompt identification of those who needed further ophthalmological care. Moreover, DDART's capacity as a validated web-based VA test indicates that it can be used in any nationwide or even European-wide remote screening initiative for vulnerable populations.

ACKNOWLEDGMENTS

- DDART can be accessed from the Democritus University server at https://ddart.med.duth.gr
- DDART – operator certification course can be accessed from the Democritus University Server at http://eddart.med.duth.gr

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APPENDICES

Questionnaire

1. Region Country

_____

2. Age

_____

3. Gender

☐ Male ☐ Female

4. Do you have a known eye disease?

☐ Yes _____ ☐ No

5. When was the last visit in an ophthalmologist?

☐ 1 < 1 month ☐ 2 < 1 year ☐ 4 < 3 years ☐ 5 Never

6. Do you use eye drops?

☐ Yes _____ ☐ No

7. Do you wear spectacles?

☐ Yes _____ ☐ No

8. Educational Level ,,,,

Primary School	☐ Yes | ☐ No
Secondary School	☐ Yes | ☐ No
College / University	☐ Yes | ☐ No
Post Graduate	☐ Yes | ☐ No

9. Systematic History

Diabetes Mellitus	☐ Yes | ☐ No
Arterial Hypertension	☐ Yes | ☐ No
Cardiac Disease	☐ Yes | ☐ No
Autoimmune Disease	☐ Yes | ☐ No
Neoplasm	☐ Yes | ☐ No

Other

Fellow _____ / Date _____

ID. _____

Subject _____

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1	Title
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	Summary
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2	Introduction
Objectives	3	State specific objectives, including any prespecified hypotheses	2-3	Introduction
Methods				
Study design	4	Present key elements of study design early in the paper	3-4	Methods
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3	Methods
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	3-4	Methods
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case		
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5	Methods
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-5	Methods
Bias	9	Describe any efforts to address potential sources of bias	4-5	Methods
Study size	10	Explain how the study size was arrived at	5	Methods
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5	Methods
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5	Methods
		(*b*) Describe any methods used to examine subgroups and interactions	5	Methods
		(*c*) Explain how missing data were addressed	5	Methods
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy		
		(*e*) Describe any sensitivity analyses		
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6	Results
		(b) Give reasons for non-participation at each stage	6	Results
		(c) Consider use of a flow diagram		
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-9	Results
		(b) Indicate number of participants with missing data for each variable of interest	6-9	Results
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	6-9	Results
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	6-9	Results
		Case-control study—Report numbers in each exposure category, or summary measures of exposure		
		Cross-sectional study—Report numbers of outcome events or summary measures		
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6-9	Results
		(*b*) Report category boundaries when continuous variables were categorized	6-9	Results
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		

Continued on next page

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	6-9	Results
Discussion				
Key results	18	Summarise key results with reference to study objectives	9-11	Discussion
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11	Discussion
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9-11	Discussion
Generalisability	21	Discuss the generalisability (external validity) of the study results	9-11	Discussion
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based		

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.