

**DISSERTATION FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (Ph.D.)**

***“Investigating health inequalities and implementing effective interventions  
for  
COVID-19 and visual acuity loss in deprived Hungarian adults”***

**By *Rahul Naresh Wasnik***

**UNIVERSITY OF DEBRECEN  
DOCTORAL SCHOOL OF HEALTH SCIENCES  
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## **List of abbreviations**

**95% CI** – 95% confidence interval  
**AAP** – American Academy of Ophthalmology  
**AMD** –age related macular degeneration  
**aOR** –adjusted odds ratio  
**BMI** –body mass index  
**CDC** – Center for Disease Control  
**COVID-19** – coronavirus disease 2019  
**cVAL** – continuous outcome variable as visual acuity loss  
**dSVI** – dichotomous outcome variable as severe visual impairment  
**ECDC** – European Center for Disease Prevention and Control  
**EU** –European Union  
**EVI** –early visual impairment  
**GP** –general practitioner  
**GPC** –general practitioners’ cluster  
**IAPB** – International Agency for the Prevention of Blindness  
**ISSP** – International Social Survey Programme  
**MERS** – Middle East Respiratory Syndrome  
**MVI** – moderate visual impairment  
**NPHC** – National Public Health Centre  
**OR** – odds ratio  
**PHC** – primary health care  
**RACGP** – Royal Australian College of General Practitioners  
**RCTs** – randomized controlled trial  
**SARS** – severe acute respiratory syndrome  
**SHCP** – Swiss Hungarian Cooperation Programme  
**SVI** – severe visual impairment  
**UK** – United Kingdom  
**USA** – United States of America  
**USPSTF** – United States Preventive Services Task Force  
**VA** – visual acuity  
**VAL** – visual acuity loss  
**WHO** – World Health Organization

# **1. Introduction**

## **1.1 Social health inequality**

Social inequality is the unequal access to benefits and rights within a society due to uneven distribution of resources based on socially defined categories. It is often associated with economic inequality, where income and wealth are distributed unevenly. This phenomenon exists in all societies and is influenced by structural factors like geography and citizen status, as well as cultural beliefs and identities. (1,2,3) Modes of social inequality includes direct and indirect social inequality.

### **Direct social inequality**

Direct social inequality arises from intentional and deliberate unfair treatment of certain groups, whether by the community or the government. This involves purposefully denying resources, opportunities, and rights to some while favoring others. For instance, laws enforcing racial segregation in schools and public places exemplify direct social inequality. (4,5,6)

### **Indirect social inequality**

Indirect social inequality stems from unfair treatment that is not intentionally planned but results from existing social structures, policies, or practices. It often emerges from biases and prejudices within society which influence unjust government regulations. (4,5,6)

### **Social health inequalities in preventive service delivery**

The welfare state refers to government measures implemented after World War 2 to provide essential services and social support such as education, healthcare, housing, social insurance, and poor relief in high income countries (7). Europe boasts the most comprehensive welfare states, utilizing various policy tools like Public Health Policies, Social transfers (such as cash aid, housing and education) and health care services to enhance citizens well-being and reduce health disparities caused by socio-economic differences (8). Despite these efforts health disparities based on income, occupation, and education persists both in Europe and other regions which is leading to lower morbidity and mortality among those with higher socio-economic status. (9,10)

Persistent health inequalities between different places can be partly attributed to variations in their unique characteristics. These “Place” characteristics play a significant role in shaping the health outcomes of their residents (11). In high income countries including England and USA have significant health disparities exist between local government areas and smaller regions. For instance, in England there is a gap of 21.5 years of healthy life expectancy for

women and 15.8 years for men between various areas. Similarly, In the capital of US, experiences a 20-year difference in life expectancy between low-income neighborhoods and wealthier ones.

These localized health inequalities are also observed in Europe, with persistent north and south disparities in countries like Italy and Spain and some of the highest regional inequalities found in France, Germany, UK and Austria. (12,13,14)

Research on placed based public health interventions, therefore is timely, especially in light of the COVID-19 pandemic given the high value-added geographical inequalities in COVID 19 associated with chronic disease inequalities. In the context of international economic uncertainty and a growing awareness among policy makers about the importance of primary prevention after the pandemic. There is a need to explore the effectiveness of locally delivered placed based approaches to improve public health (physical environment, social environment and economic environment). (15,16,17,18)

Health equity the most compelling, straight forward and concise definition that ever been offered and the one is most widely used from “Margaret Whitehead in UK defines ***“Differences which are unnecessary and avoidable, but in addition are considered unfair and unjust”*** (164)

Achieving health equity in prevention is highly challenging due to two main reasons:

- 1) First, nearly everyone is eligible for prevention services. Disparities can emerge across various socio-demographic dimensions outlined in Healthy People 2020.
- 2) Second, the effectiveness of prevention depends on specific clinical pathways, leading to potential gaps for disadvantaged groups. This complexity arises from numerous sociodemographic dimensions where disparities may exist, multiplied by the number of preventive services considered. (19)

## **1.2 Screening for visual acuity loss**

According to the World Health Organization (**WHO**), 2.2 billion people globally suffer from visual impairment mainly caused by uncorrected refractive errors, cataracts, and age-related macular degeneration (**AMD**). The affected population is dominated by elderly people. This unavoidable cause is becoming a more dominant determinant as the world population ages (20).

Conversely, investigations conducted at both country and within-country social group levels conclusively show that social deprivation is a significant risk factor for visual impairment (21,22). Social inequality used to be attributed to population-level variability in health

literacy, the availability of health care, and the organization of ophthalmologic care. Although the specific mechanisms behind this association have not been properly explored, primary health care plays an important role in early detection, diagnosis, and screening, which are the critical components for an optimal approach to visual impairment [23,24]. To enable eye care service providers, general medical practitioners, and public health authorities to reduce this inequality, the WHO recommends regular monitoring of the effectiveness of ophthalmologic care. This recommendation is a part of the global plan of action for universal eye health and emphasizes the importance of providing basic eye care at affordable prices for all communities (25,26).

Progressive vision loss affects many facets of daily life, such as reading, mobility, and independence, greatly impacting quality of life, including economic status and education level, leading to the loss of productivity (27,28). Progressive vision loss impairs mental health and increases the risk of traumas as well (29-32).

Considering that the prevalence of undiagnosed visual impairment is very high, and visual acuity checking is safe and cheap, population-based screening seems to be an important tool to reduce the consequences of undiagnosed visual impairment (33).

Direct evidence of the effectiveness of screening is missing because several randomized controlled trials (on outcomes of visual acuity, morbidity, mortality, general or vision related quality of life, functional status, and cognition) failed to demonstrate the benefit of programmatic vision screening in adults. These trials were essentially from resource-rich settings of affluent countries and were generally limited by small sample sizes, low intervention uptake, substantial losses to follow-up, and the use of self-reported primary outcomes (34). The causal association between uncorrected visual impairment, mental and behavioral changes, and elevated mortality rates is still subject to uncertainty. In fact, there is a dearth of circumstantial data supporting the advantages of using refractive lenses (35-41).

The US Preventive Services Task Force (**USPSTF**) and other organizations, such as the American Academy of Family Physicians and the Canadian Task Force on Preventive HealthCare, for population-based screening recommendations acknowledge these ambiguities. Their statement advocates that the existing evidence is insufficient to assess the balance of benefits and harms of screening for impaired visual acuity in asymptomatic adults 65 years or older (42-45). Perhaps other organizations such as the American Academy of Ophthalmology and the Royal Australian college of General Practitioners potentially hold a more favorable stance towards regular screening, emphasizing the effectiveness of refractive lenses, cataract surgery, and treatment for AMD (46,47). The USPSTF also suggests for

adults who screen positive, it is essential to guide people towards appropriate follow up care, so that they can receive the treatment support they need for their reduced ability (48,49).

Considering the well-known social inequalities of visual acuity loss and the huge impact of care accessibility on the prognosis of eye disorders, the effectiveness of screening for visual acuity loss is highly dependent on the social and institutional status of a country. It is explicitly acknowledged by the USPSTF that well-designed primary care studies are required to clarify the potential benefits of screening that evaluate new vision screening accompanied by proper referral to appropriate follow-up care and that are targeted to higher risk populations (49).

In Hungary, visual acuity examination organized by population-based screening is recommended in general practice by a ministerial decree (Annex No: 2 of Act 51/1997 (XII.18) NM). The first examination is scheduled for 21 years of age, which should be followed by a yearly examination for those beyond the age of 65. Unfortunately, there is no monitoring for the implementation of decree-defined screening, and there are no routine statistics on the prevalence of visual acuity loss either in the general population or in the sociodemographic strata.

According to a recent representative survey among 50+ year-old Hungarian adults, the prevalence of less than 0.5 visual acuity is 13.4%. The leading causes were cataracts (47.1%), refractive error (30.2%), AMD and another posterior segment disease (14.5%), followed by glaucoma (2.7%), and diabetic retinopathy (2.4%). This etiological background is close to the reported western European pattern (50).

The prevalence of less than 0.5 visual acuity was 8.8% among 20- to 64-year-old Hungarian adults in a regional survey. Among individuals wearing glasses with visual acuity <0.5 was 77.1%. However, the individuals belonging to Roma minority were significantly lower (14.3%). These findings highlight a huge social inequality in eye care within the Hungarian population (51).

The ineffectiveness of Hungarian eye care in the early diagnosis of visual impairment is reflected in the observed much higher prevalence of vision impairment due to uncorrected presbyopia (when the best-corrected-distance visual acuity is 6/12 or better), which is not accompanied by an observed much higher prevalence of blindness (<3/60 vision in the better eye in presentations) and mild-to-severe vision loss (<6/18-3/60 vision in bilateral presentations) compared to rich resource rich settings (Wills eye institute (Philadelphia, USA), Massachusetts eye and ear infirmary (Boston, USA), Westmead hospital (Sydney, Australia), Bascome Plamer eye institute (Miami, USA) where relevant RCTs have been

implemented. Effective treatments (cataract surgery, refractive error correction, medications, low vision aids) are available for common causes of impaired visual acuity in older adults (50).

### **1.3 Preventive measures for COVID-19 epidemic**

On 30 January 2020, the WHO declared the SARS-CoV-2 outbreak a public health emergency of international concern (52,53). As of 3 May 2021, 169,597,415 confirmed cases had been reported worldwide [54]. Even before the pandemic was declared, the prevalence of coronavirus disease 2019 (**COVID-19**), caused by SARS-CoV-2, had increased significantly in some European countries and placed a strain on healthcare systems (55). The European Center for Disease Prevention and Control (**ECDC**) estimates that 32,430,146 cases and 721,375 deaths had been recorded in the European Union by 31 May 2021 (56). Due to the restricted effectiveness of treatment for SARS-CoV-2 infection, before vaccines were developed and widely administered, epidemiological measures (sanitation, hygiene, testing, case isolation, contact tracing, and quarantine) were the only means of containing SARS-CoV-2 (57-61). Therefore, the effectiveness of epidemiologic control measures determined the extent and consequences of the COVID-19 epidemic. “Which control measures have been more or less successful to mitigate the spread?” (62) and “Which population areas will sustain  $R_0$  (reproductive number)  $>1$ , and what are the determinants of this degree of transmission?” [63] were among the open questions formulated at the beginning of the pandemic. Until now, these kinds of questions have remained unanswered, and need thorough investigation to draw conclusions from experiences of COVID-19 management.

The number of ECDC-reported COVID-19-related deaths in Hungary was 29,733 by the end of May 2021. While the relative risk of infection in Hungary (cumulative rate of infection: 8.2%) compared to the EU average (cumulative rate of infection: 7.2%) was 1.14; the relative risk for COVID-19-related death was 1.89 in Hungary. The relative risk of COVID-19-related death corrected for the infection rate was 1.66 in Hungary, and the number of expected deaths was 17,896 on the basis of the EU infection and death rates. Consequently, 11,837 deaths were attributable to condition in Hungary that deviated from the EU average which determined the effectiveness of epidemic control measures and the treatment of infected patients (64).

Detailed analysis of the excess mortality confirmed the remarkable excess deaths during the COVID-19 pandemic in Hungary. It was demonstrated that Hungary belonged to the tertile of the EU countries with the highest excess mortality rates (65).

According to ecological studies, the socioeconomic position influenced the epidemic in Hungary. The settlement level deprivation showed a significant inverse association with infection rate and significant association with mortality rate (66). Deprivation played a prominent negative role in terms of vaccination coverage as well. It is important to note that adherence with epidemiological measures has not yet been evaluated in Hungary (67).

The COVID-19 pandemic highlighted the interconnectedness, interdependence and placing significant pressure on world leaders, policy makers and public health authorities to make ethically complex decisions regarding public health containment measures. In democratic societies decision making processes must be transparent and justified (68). The state carries the responsibility to safeguard and protect the health of its populations which may necessitate implementing public health measures such as movement restrictions, Mandatory quarantine, isolation (when infected individual poses a threat to public health) while these may temporarily restrict individual liberties, their implementation is deemed justified. (69)

Regular COVID-19 screening testing can help to identify infections early and prevent the spread of the virus. Testing is particularly important for individuals with symptoms or those who been in close contact with someone has tested positive (70). Epidemiological data is essential for public health planning, but it should be protecting identities (anonymized data) and respect privacy. Non-anonymized data can be collected without consent if it prevents harm to others (71).

Contact tracing plays a pivotal role in effectively controlling the spread of any infectious disease. However, in case of COVID-19, lack of preparedness and insufficient information pose a significant challenge in tracing exposed or suspected cases. These challenges include individuals being reluctant to provide accurate contact information upon arrival in the country and concerns regarding privacy rights, stigma and mandatory isolation or quarantine, which can sometimes be unsanitary (72).

Vaccination seen to be fundamentally a confrontation between humanity and the virus. The humanity emerged as victorious in this race, and it is now moral and ethical obligation of the world to achieve herd immunity through widespread testing and vaccination ensuring protection to everyone (73,74)

Vulnerable groups have been disproportionately affected by the epidemic and associated measures. Here are some of the steps taken to support the vulnerable groups all over world:

### **1. Addressing socio-economic position, immigration status and language abilities**

Vulnerable populations such as migrants, impoverished communities and individuals with disabilities who were already marginalized prior to the emergence of the coronavirus, who

experienced a disproportionate impact of lockdown measures and other responses implemented to address the health crisis. Among those impoverished communities and immigrant workers were particularly affected. Undocumented migrants and refugees are considered vulnerable due to their legal status in the host country as they faced challenges in accessing essential services and medical care without official documents. This issue becomes prominent in the context of vaccination programs (75).

## **2. Reviewing conventional care standards and adjustments to protocols**

In response to widespread closures, advanced economies have implemented various measures to mitigate socio-economic repercussions. These measures include deferring tax refunds, increasing financial assistance, providing subsidies to workers, offering compensation, and enhancing unemployment insurance benefits (73). Conversely, less developed countries have fewer resources to manage the pandemic and leading to not only an economic crisis but also a systemic human development crisis (76). People with disabilities face disparities in accessing public health messages. To address this, all communications should be made available in simple language, accessible formats, disseminated through mass media channels. The disruption in services further affects the marginalized disability groups restricting their access to healthcare which can worsen their existing daily challenges (77).

## **3. Unmet non-COVID-19 healthcare needs**

During the critical phase of outbreak, when healthcare services are disrupted with management of COVID-19-cases, older adults and individuals with chronic diseases have encountered with unmet healthcare needs unrelated to COVID-19 due to strain on healthcare resources (78-80).

### **1.4 Objectives**

#### ***“Related to the screening for visual acuity loss”:***

1. To determine the prevalence of visual acuity loss,
2. To identify the influencing factors of visual acuity loss,
3. To evaluate the effectiveness of primary health care-based visual acuity loss screening,
4. To formulate recommendations to improve the practice of visual acuity loss screening.

#### ***“Related to the provision of COVID-19 epidemiologic control measures”:***

1. To describe patient experiences with COVID-19-related testing, contact tracing, and vaccination,

2. To evaluate the impact of sociodemographic, lifestyle, and clinical factors on patient-reported epidemiological measures,
3. To determine the contribution of non-perfect epidemiological control measures to the mortality excess.
4. To formulate recommendations to prevent malpractice in controlling epidemics.

## **2. Methods**

### **2.1 Setting of the visual acuity survey**

The Swiss-Hungarian Cooperation Programme entitled ‘Public Health Focused Model Programme for Organising Primary Care Services Backed by a Virtual Care Service Centre’ was a pilot initiative aimed at establishing on the foundation of the Hungarian primary healthcare (**PHC**) reform. The goal was to enhance the overall health status and reduce health disparities by integrating prevention and health promotion into primary health care (81).

The program was guided by the Health 2020 concept, which emphasized that primary healthcare system should not only provide traditional patient care, but also prioritize health promotion, disease prevention, and the health restoration in the local community. Additionally, it also focuses on the rehabilitation of people with chronic diseases. The programme was implemented in two disadvantaged regions of Hungary, namely North Hungary and Northern Plain. In these regions, the four clusters of General Practitioners (**GPC**) were established to serve 32,655 individuals and 30% of whom belong to the Roma ethnic group, which was the most vulnerable minority in the country. Each GPC consisted of six GPs, which were located close to each other within a radius of about 50 km.

One component of the program’s services was a population based, organized general health check (**GHC**) for all adults regardless of their health status (82).

As part of the GHC, a questionnaire was applied. A physical examination was performed; medications along with laboratory parameters and cardio-metabolic primary care data were collected. GHC was launched on 1<sup>st</sup> October 2013, and 5036 patients participated by 30<sup>th</sup> September 2014 (83). The presented investigation was a secondary analysis of the databases built by the GHC.

## 2.2 Setting of the COVID-19 survey

In this study, we performed secondary data analysis using the International Social Survey Programme (ISSP) survey on the personal experiences related to the COVID-19 epidemic control measures. ISSP is an international survey conducted every year in the field of social sciences to bring various importance to the specific topic theme. In this survey, “Health and health care” modules contain health related questions.

The COVID-19 investigation was a population-based survey cross-sectional study. Data were obtained from the 2021 ISSP survey conducted from 15th March to 30 May 2021 during the third wave of COVID 19. The survey was completed with COVID-19 epidemic related questions. Data from the survey database were provided for the analysis. A representative sample of 1008 Hungarian adults aged over 18 years was randomly selected from the country’s whole population (using the national registry of the Hungarian population as the sampling frame) and interviewed in person by trained interviewers (84) and other supplementary databases include 1) Hungarian Mid census 2016 2) European center for diseases prevention and control 2021 3) Hungarian Implementation of the European health interview survey 2019.

## 2.3 Data collection for visual acuity survey

The GHC was conducted by a team of trained public health practitioners and nurses (85). The demographics characteristics of the patients were described by the age, gender, self-declared ethnicity (distinguishing **Roma and non-Roma**). The socioeconomic status of participants was assessed by considering their employment status (categorizing them as **employed and unemployed**) and the level of education is (**non-completed primary school, completed primary school, secondary school without graduation, secondary school with graduation, higher education**).

Because the regular ophthalmologic examination is a compulsory part of the care for high prevalence chronic diseases (**hypertension and diabetes**), patients’ blood pressure and fasting blood glucose concentration were measured and the cardiometabolic history was registered in the GHC and, they were categorized into one of the following subgroups:

1. no existing disease or treatment: patients with normal blood pressure and normal fasting blood glucose concentration
2. diagnosed and properly treated

3. diagnosed but inadequately treated
4. an unknown and therefore untreated disease group.

A blood pressure of 140/90 mmHg (average of two measurements) and a fasting blood glucose of 7 mmol/L were set as cutoff values for normal values. Patients without diagnosed diseases whose readings were below the cutoff points were classified as normotensive or normoglycemic.

Visual acuity was assessed using a Snellen-type Kettesy table which consisted of optotypes arranged in rows. The optotypes on each row were designed in a way that they decreased in size, allowing for the evaluation of a patient's reading and observing abilities. The measurement of visual acuity (**VA**) involved determining the smallest optotypes that a patient could read and expressing it as a ratio of the distance from the patient to the test chart and the distance at which the optotype could be detected by a health eye.

The criteria for visual acuity set by the council of the European communities' directive on driving licenses (Directive 91/439/EEC) were used as a reference. According to these guidelines, an individual is considered eligible for a driving license if their best corrected binocular visual acuity reaches at least 0.5. This standard is also applied in occupational medical practice to calculate the degree of dis-ability for disadvantaged workers in Hungary. All participants were characterized with a continuous outcome variable as visual acuity loss (**cVAL**, assessing the severity of total ocular damage by calculating  $1-VA$ ) and with a dichotomous outcome variable as severe (**cVAL** is less than 0.5) visual impairment (**SVI**).

## **2.4 Data collection for COVID 19 survey**

In this study, each outcome measure were determined by the participants' self -declaration. COVID-19 infection was ascertained if a participant had an infection with SARS-CoV-2 virus confirmed by laboratory findings. Individuals who were tested for SARS-CoV-2 infection under any circumstances before the time of the survey were distinguished from those who did not undergo testing. Patients with confirmed infection declared whether they were interviewed by any healthcare professionals or epidemiologist about their contact persons.

Contact tracing measures were implemented and registered accordingly. Concurrently, a mass vaccination campaign was in progress at the time of the data collection, Partial vaccination was rare among the Hungarian adults, as the majority of the individuals who had received partial vaccination during the survey period had later been booster properly (86). There was no reason to make distinction between partially and fully vaccinated persons.

Therefore, participants were considered vaccinated if they had received at least one dose of the SARS-CoV-2 vaccine before the survey.

Participants' sex and age were registered along with their highest level of education. To analyze the data effectively, the participants' ages were categorized into three groups: 18-40 years (representing young adults), 41-70 years (middle-aged-adults), and 71-105 years (older adults). The participant-level of education (primary, secondary and tertiary) was distinguished. Employed and not employed categories were applied.

Non-regular alcohol drinkers those consuming at least 4 drinks a day but not more frequently than once a month and regular drinkers with a more intense alcohol drinking history were identified regular and non-regular smoking dichotomization was used irrespective of the smoking intensity. The participant's BMI was calculated using self-reported weight and height and analyzed as continuous variable. The presence or absence of chronic disease were registered for each participant, regardless of the disease type.

## **2.5 Statistical analysis for visual acuity survey**

The visual acuity investigation was performed on patients who did not wear glasses or contact lenses and were not known to have an eye care provider. Therefore, all patients who wore glasses or contact lenses or had seen an ophthalmologist within one year before the examination date were excluded from the study. For the analyses, we used data from the complete records.

Adjusted linear regression coefficients (**b**) with the corresponding 95% confidence intervals (**95% CI**) from multivariate linear regression analysis were used to identify the protective and risk factors for cVAL. Factors influencing the dSVI were determined by multivariable logistic regression analysis. The results are presented as odds ratios (**ORs**) with corresponding 95% CIs.

Each statistical analysis was performed on the entire study population and on the subgroup of patients older than 65 years. Statistical analyses were performed using PASW Statistics (version 18.0, SPSS Inc., Chicago, IL, USA)

## **2.6 Statistical analysis for COVID 19 survey**

Firstly, we applied chi-square and unpaired t-tests were used to assess the association between the explanatory and outcome variables. Multivariable logistic regression models were applied to describe the influence of socio-demographics parameters (age group, sex and

education), lifestyle (**BMI**, regular smoking and regular alcohol drinking) and the presence of chronic disease on the outcome variables (test-confirmed SARS-Cov-2 infection, testing, contract tracing among infected individuals and vaccination). The results were reported as ORs with corresponding 95% CI. The ISSP dataset was analyzed using SPSS version 26 (IBM SPSS statistics for Windows, version 26.0 Armonk, NY, USA: IBM Corp).

## **2.7 Ethical approval for visual acuity survey**

The study protocol was approved by the Ethics Committee of the Hungarian National Scientific Council for Health (TUKÉB 16676-3/2016/EKU, 0361/16). All participants signed an informed consent form before the health check data collection started.

## **2.8 Ethical approval for COVID 19 survey**

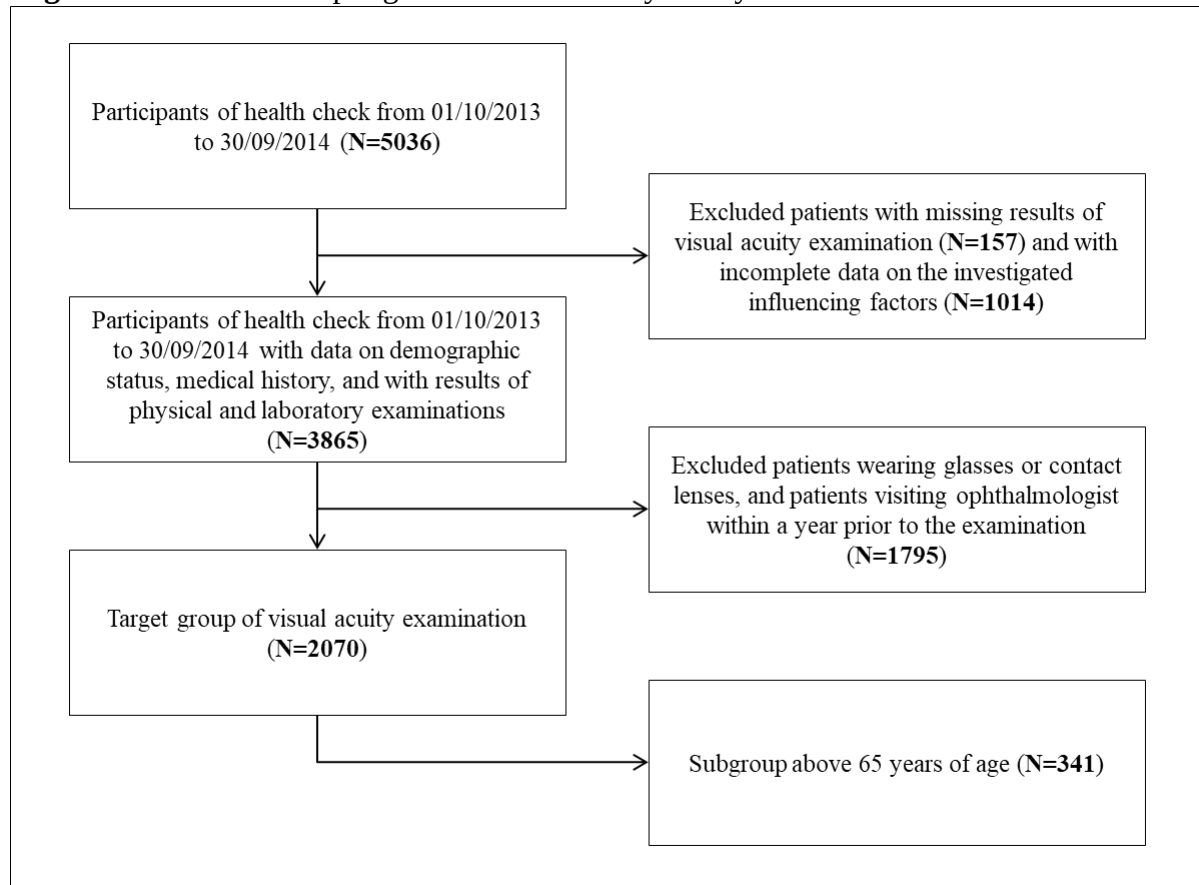
Ethical approval for the secondary analysis of anonymized data from ISSP was not required by Hungarian

### 3. Results

#### 3.1 Sample of the visual acuity survey

The sampling process is summarized in **(Figure 1)**. After this exclusion of patients with incomplete records, 2070 patients remained, who met all the inclusion criteria and served as the target population for acuity loss screening.

**Figure 1.** Process of sampling for the visual acuity survey



#### 3.2 Descriptive statistics of investigated sample of visual acuity survey

The descriptive statistics (for the whole target group and subgroup of patients over 65 years of age) are summarized below **(Table 1)**. Visual acuity less than 0.5 could be detected in 3.7% of the target group and in 9.1% of adults over 65 years of age. More females below the age of 65 participated than males. Thus indicates a higher representation of females in the young adult's population. The average age of the participants in the study was 43.1 years among the age groups who were not above 65 years. **(Table 2)**

**Table 1.** Characteristics of the study population

|                                     |                                     | <b>Adults (18+ years of age)</b> | <b>Above 65 years of age</b> |
|-------------------------------------|-------------------------------------|----------------------------------|------------------------------|
| <b>Sex</b>                          | Male                                | 768 (37.1%)                      | 140 (41.1%)                  |
|                                     | Female                              | 1302 (62.9%)                     | 201 (58.9%)                  |
| <b>Age</b>                          | Mean ( $\pm$ SD)                    | 47.8 ( $\pm$ 15.9)               | 71.9 ( $\pm$ 5.52)           |
| <b>Education</b>                    | Non-completed primary school        | 233 (11.3%)                      | 45 (13.2%)                   |
|                                     | Completed primary school            | 640 (30.9%)                      | 148 (43.4%)                  |
|                                     | Secondary school without graduation | 511 (24.7%)                      | 57 (16.7%)                   |
|                                     | Secondary school with graduation    | 533 (25.7%)                      | 70 (20.5%)                   |
|                                     | Higher education                    | 153 (7.4%)                       | 21 (6.2%)                    |
| <b>Employment</b>                   | Unemployed                          | 1079 (52.1%)                     | 336 (98.5%)                  |
|                                     | Employed                            | 991 (47.9%)                      | 5 (1.5%)                     |
| <b>Ethnicity</b>                    | Non-Roma                            | 1825 (88.2%)                     | 334 (97.9%)                  |
|                                     | Roma                                | 245 (11.8%)                      | 7 (2.1%)                     |
| <b>Hypertension</b>                 | Normotensive                        | 882 (42.6%)                      | 31 (9.1%)                    |
|                                     | Untreated hypertension              | 279 (13.5%)                      | 47 (13.8%)                   |
|                                     | Insufficiently treated hypertension | 487 (23.5%)                      | 144 (42.2%)                  |
|                                     | Properly treated hypertension       | 422 (20.4%)                      | 119 (34.9%)                  |
| <b>Diabetes</b>                     | Normoglycemic                       | 1786 (86.3%)                     | 246 (72.1%)                  |
|                                     | Untreated diabetes                  | 75 (3.6%)                        | 24 (7.0%)                    |
|                                     | Insufficiently treated diabetes     | 128 (6.2%)                       | 41 (12.0%)                   |
|                                     | Properly treated diabetes           | 81 (3.9%)                        | 30 (8.8%)                    |
| <b>Visual acuity</b>                | Visual acuity $\geq 0.5$            | 1994 (96.3%)                     | 310 (90.9%)                  |
|                                     | Visual acuity $< 0.5$               | 76 (3.7%)                        | 31 (9.1%)                    |
| <b>Total number of participants</b> |                                     | 2070 (100%)                      | 341 (100%)                   |

Regarding education, most of the participants had completed primary school (28.5%), secondary school with graduation (26.8%) and secondary school education without graduation (26.3%), while the participants had very low higher education (7.6%) among the adults. In the study, the adults are mainly employed (57%). The non-Roma was more represented than Roma among adults' population. The adult population was more normotensive and normoglycemic. The visual acuity  $\geq 0.5$  among adults is 97.4%. (**Table 2**)

### 3.3 Descriptive statistics of investigated sample of COVID-19 survey

Females, middle-aged adults (41–70 years old), employed persons, and secondary educated adults predominated the investigated sample. This sociodemographic composition resembled Hungarian national reference values; however, the deviations were statistically significant apart from the employment ratio (**Table 3**).

**Table 2.** Characteristics of the study population not above 65 years of age of visual acuity survey

| Influencing Factors          |                                     | N (%)              |
|------------------------------|-------------------------------------|--------------------|
| Sex                          | Male                                | 628 (36.3%)        |
|                              | Female                              | 1101 (63.7%)       |
| Age                          | Mean ( $\pm$ SD)                    | 43.1 ( $\pm$ 12.6) |
| Education                    | Non-completed primary school        | 188 (10.9%)        |
|                              | Completed primary school            | 492 (28.5%)        |
|                              | Secondary school without graduation | 454 (26.3%)        |
|                              | Secondary school with graduation    | 463 (26.8%)        |
|                              | Higher education                    | 132 (7.6%)         |
| Employment                   | Unemployed                          | 743 (43%)          |
|                              | Employed                            | 986 (57%)          |
| Ethnicity                    | Non-Roma                            | 1491 (86.2%)       |
|                              | Roma                                | 238 (13.8%)        |
| Hypertension                 | Normotensive                        | 851 (49.2%)        |
|                              | Untreated hypertension              | 232 (13.4%)        |
|                              | Insufficiently treated hypertension | 343 (19.8%)        |
|                              | Properly treated hypertension       | 303 (17.5%)        |
| Diabetes                     | Normoglycemic                       | 1540 (89.1%)       |
|                              | Untreated diabetes                  | 51 (2.9%)          |
|                              | Insufficiently treated diabetes     | 87 (5%)            |
|                              | Properly treated diabetes           | 51 (2.9%)          |
| Visual acuity                | Visual acuity $\geq 0.5$            | 1684 (97.4%)       |
|                              | Visual acuity $< 0.5$               | 45 (2.6%)          |
| Total number of participants |                                     | 1729               |

The observed frequencies of regular smoking and alcohol drinking were 27.9% and 12.8%, respectively. The prevalence of at least one chronic disease was 27.2%, and 41.6% of the participants had a normal BMI. The European Health Interview Survey Hungarian Implementation dataset was used to generate reference numbers, and the investigated sample was representative with respect to the prevalence of regular smoking. Regular alcohol consumption and chronic disease were somewhat less prevalent among ISSP survey participants, and a normal BMI was somewhat more prevalent (**Table 3**).

The prevalence of test-confirmed SARS-CoV-2 infection was 12.1% in this sample. A total of 33.7% of participants were tested, and 74.8% of the infected participants were contact traced. The observed vaccination coverage was 52.4%. The reported ratios of test confirmed infection and vaccination were higher among ISSP survey responders than the communicated national reference values (**Table 3**). After conducting a post-hoc analysis, we found a significant association between age and test confirmed SARS-CoV-2 Infection in both middle-aged individuals ( $p= 0.036$ ) and older age groups ( $p= 0.002$ ) (**Table 4**). Moreover,

association between age and testing for SARS-CoV-2 infection was found to be highly significant in both middle-aged ( $p<0.001$ ) and older age groups ( $p<0.001$ ) (**Table 5**). Furthermore, we also found an association between age and contact tracing was found to be statistically significant in both middle-age ( $p=0.012$ ) and younger age groups ( $p=0.018$ ) (**Table 6**). The association between age and vaccination against COVID19 was resulted statistically significant in all age groups (younger age  $p<0.001$ ), middle aged  $p=0.008$ , older age group  $p<0.001$ ). (**Table 7**)

**Table 3.** Sociodemographic composition, lifestyle factors and chronic disease occurrence of the sample investigated in the ISSP 2021 survey with reference data from the Hungarian population.

| Influencing Factor |                           | ISSP survey<br>(95% confidence<br>interval) | Hungarian reference<br>(95% confidence<br>interval) |
|--------------------|---------------------------|---------------------------------------------|-----------------------------------------------------|
| Age*               | 18-40 years               | 26.8% (24.6- 29.5)                          | 23.2%                                               |
|                    | 40-70 years               | 60.1% (57.1-63.1)                           | 55.0%                                               |
|                    | 71-105 years              | 13.1% (11.1-15.1)                           | 21.8%                                               |
| Sex*               | Male                      | 40.9% (37.9-43.9)                           | 47.5%                                               |
|                    | Female                    | 59.1% (56.1- 62.1)                          | 52.5%                                               |
| Education*         | Primary                   | 16.4% (14.1-18.7)                           | 23.2%                                               |
|                    | Secondary                 | 68.8% (66.0- 71.7)                          | 55.0%                                               |
|                    | Tertiary                  | 14.8% (12.6-17.0)                           | 21.8%                                               |
| Employment*        | Employed                  | 65.2% (62.1-68.1)                           | 64.0%                                               |
|                    | Not-employed              | 34.6% (31.7-37.6)                           | 36.0%                                               |
| Smoking**          | Regular smoking           | 27.9% (25.1-30.6)                           | 26.3% (25.1-27.4)                                   |
|                    | Not regular smoking       | 72% (69.3-74.8)                             | 81.8% (80.6-83.0)                                   |
| Drinking alcohol** | Regular drinking          | 12.8% (10.7-14.8)                           | 18.2% (17.0-19.4)                                   |
|                    | Not regular drinking      | 87.1% (85.1-89.2)                           | 81.8% (80.6-83.0)                                   |
| BMI**              | Thin                      | 4.1% (2.8-5.3)                              | 2.5% (2.1-2.9)                                      |
|                    | Normal                    | 41.6 % (38.5-44.7)                          | 36.8% (35.5-38.0)                                   |
|                    | Overweight                | 37.2 (34.2-40.3)                            | 34.6% (33.3-35.8)                                   |
|                    | Obese                     | 17.1 % (14.7-19.5)                          | 24.8% (23.7-25.9)                                   |
| Chronic Diseases** | Present                   | 27.2% (24.5-30.0)                           | 34.8 % (31.9-37.8)                                  |
|                    | Absent                    | 72.8% (70.0-75.5)                           | 65.2 % (62.2-68.1)                                  |
| Infection***       | (test confirmed)          | 12.1 % (10.1-14.2)                          | 8.2%                                                |
| Testing            | (under any circumstances) | 33.7% (30.8-36.6)                           | #                                                   |
| Tracing            | (among infected)          | 74.8% (67.0-82.6)                           | ##                                                  |
| Vaccination***     | (by at least one dose)    | 52.4% (49.3 -55.5)                          | 50.9%                                               |

\* Reference: Hungarian Mid-term Census, 2016 [87].

\*\* Reference: Hungarian implementation of the European Health Interview Survey, 2019 [88].

\*\*\* Reference: European Centre for Disease Prevention and Control, 2021 [89].

# Hungary discontinued reporting on testing frequency at the end of 2020 to the ECDC. There is no national reference value for the study period.

## Contact tracing was not included in the ECDC monitoring system.

Regarding the level of education, a statistically significant association was observed between education and test confirmed SARS-CoV2 infection particularly among individuals with primary education ( $p=0.006$ ) (**Table 8**). Similarly, the association between education level and testing for SARS-CoV2 infection was statistically significant in both primary ( $p<0.001$ ) and tertiary education ( $p<0.001$ ) (**Table 9**). However, no significant association was found between education level and contract tracing. (**Table 10**). Conversely, the noteworthy correlation between education level and vaccination against COVID-19 showing significance among individuals with both secondary education ( $p<0.001$ ) and tertiary education ( $p<0.001$ ) (**Table 11**).

**Table 4.** Post-hoc analysis for the chi-square test on the association between age and test confirmed SARS-CoV2 infection.

| Age groups    |                   | Not infected | Infected | Total |
|---------------|-------------------|--------------|----------|-------|
| <b>Middle</b> | Observed          | 508          | 82       | 590   |
|               | Expected          | 518.503      | 71.497   | 590   |
|               | Adjusted Residual | -2.097       | 2.097    | -     |
|               | P-value           | 0.036        |          | -     |
| <b>Older</b>  | Observed          | 125          | 5        | 130   |
|               | Expected          | 114.246      | 15.754   | 130   |
|               | Adjusted Residual | 3.103        | -3.103   | -     |
|               | P-value           | 0.002        |          | -     |
| <b>Young</b>  | Observed          | 230          | 32       | 262   |
|               | Expected          | 230.251      | 31.749   | 262   |
|               | Adjusted Residual | -0.055       | 0.055    | -     |
|               | P-value           | 0.956        |          | -     |
| <b>Total</b>  | Observed          | 863          | 119      | 982   |
|               | Expected          | 863          | 119      | 982   |

**Table 5.** Post-hoc analysis for the chi-square test on the association between age and testing for SARS-CoV2 infection

| Age groups    |                   | Not tested | Tested  | Total |
|---------------|-------------------|------------|---------|-------|
| <b>Middle</b> | Observed          | 368        | 238     | 606   |
|               | Expected          | 401.595    | 204.405 | 606   |
|               | Adjusted Residual | -4.571     | 4.571   | -     |
|               | P-value           | <0.001     |         | -     |
| <b>Older</b>  | Observed          | 115        | 17      | 132   |
|               | Expected          | 87.476     | 44.524  | 132   |
|               | Adjusted Residual | 5.435      | -5.435  | -     |
|               | P-value           | <0.001     |         | -     |
| <b>Young</b>  | Observed          | 185        | 85      | 270   |
|               | Expected          | 178.929    | 91.071  | 270   |
|               | Adjusted Residual | 0.913      | -0.913  | -     |
|               | P-value           | 0.361      |         | -     |
| <b>Total</b>  | Observed          | 668        | 340     | 1008  |
|               | Expected          | 668        | 340     | 1008  |

**Table 6.** Post-hoc analysis for the chi-square test on the association between age and contact tracing

| Age groups    |                   | Not contact traced | Contact traced | Total |
|---------------|-------------------|--------------------|----------------|-------|
| <b>Middle</b> | Observed          | 23                 | 67             | 90    |
|               | Expected          | 29.318             | 60.682         | 90    |
|               | Adjusted Residual | -2.519             | 2.519          | -     |
|               | P-value           | 0.012              |                | -     |
| <b>Older</b>  | Observed          | 3                  | 4              | 7     |
|               | Expected          | 28.571             | 4.286          | 7     |
|               | Adjusted Residual | 0.596              | -0.596         | -     |
|               | P-value           | 0.551              |                | -     |
| <b>Young</b>  | Observed          | 17                 | 18             | 35    |
|               | Expected          | 11.402             | 23.598         | 35    |
|               | Adjusted Residual | 2.355              | -2.355         | -     |
|               | P-value           | 0.018              |                | -     |
| <b>Total</b>  | Observed          | 43                 | 89             | 132   |
|               | Expected          | 43                 | 89             | 132   |

**Table 7.** Post-hoc analysis for the chi-square test on the association between age and vaccination against COVID-19

| Age groups    |                   | Not vaccinated | Vaccinated | Total |
|---------------|-------------------|----------------|------------|-------|
| <b>Middle</b> | Observed          | 338            | 268        | 606   |
|               | Expected          | 317.429        | 288.571    | 606   |
|               | Adjusted Residual | 2.65           | -2.65      | -     |
|               | P-value           | 0.008          |            | -     |
| <b>Older</b>  | Observed          | 113            | 19         | 132   |
|               | Expected          | 69.143         | 62.857     | 132   |
|               | Adjusted Residual | 8.199          | -8.199     | -     |
|               | P-value           | <0.001         |            | -     |
| <b>Young</b>  | Observed          | 77             | 193        | 270   |
|               | Expected          | 141.429        | 128.571    | 270   |
|               | Adjusted Residual | -9.175         | 9.175      | -     |
|               | P-value           | <0.001         |            | -     |
| <b>Total</b>  | Observed          | 528            | 480        | 1008  |
|               | Expected          | 528            | 480        | 1008  |

**Table 8.** Post-hoc analysis for the chi-square test on the association between level of education and test confirmed SARS-CoV2 infection

| Education        |                   | Not infected | Infected | Total |
|------------------|-------------------|--------------|----------|-------|
| <b>Primary</b>   | Observed          | 152          | 9        | 161   |
|                  | Expected          | 141.49       | 19.51    | 161   |
|                  | Adjusted Residual | 2.776        | -2.776   | -     |
|                  | P-value           | 0.006        |          | -     |
| <b>Secondary</b> | Observed          | 585          | 90       | 675   |
|                  | Expected          | 593.203      | 81.797   | 675   |
|                  | Adjusted Residual | -1.73        | 1.73     | -     |
|                  | P-value           | 0.084        |          | -     |
| <b>Tertiary</b>  | Observed          | 126          | 20       | 146   |
|                  | Expected          | 128.308      | 17.692   | 146   |
|                  | Adjusted Residual | -0.634       | 0.634    | -     |
|                  | P-value           | 0.526        |          | -     |
| <b>Total</b>     | Observed          | 863          | 119      | 982   |
|                  | Expected          | 863          | 119      | 982   |

**Table 9.** Post-hoc analysis for the chi-square test on the association between level of education and testing for SARS-CoV2 infection

| <b>Education</b> |                   | <b>Not tested</b> | <b>Tested</b> | <b>Total</b> |
|------------------|-------------------|-------------------|---------------|--------------|
| <b>Primary</b>   | Observed          | 139               | 26            | 165          |
|                  | Expected          | 109.345           | 55.655        | 165          |
|                  | Adjusted Residual | 5.34              | -5.34         | -            |
|                  | P-value           | <0.001            |               | -            |
| <b>Secondary</b> | Observed          | 453               | 241           | 694          |
|                  | Expected          | 459.913           | 234.087       | 694          |
|                  | Adjusted Residual | -0.994            | 0.994         | -            |
|                  | P-value           | 0.320             |               | -            |
| <b>Tertiary</b>  | Observed          | 76                | 73            | 149          |
|                  | Expected          | 98.742            | 50.258        | 149          |
|                  | Adjusted Residual | -4.269            | 4.269         | -            |
|                  | P-value           | <0.001            |               | -            |
| <b>Total</b>     | Observed          | 668               | 340           | 1008         |
|                  | Expected          | 668               | 340           | 1008         |

**Table 10.** Post-hoc analysis for the chi-square test on the association between level of education and contact tracing

| <b>Education</b> |                   | <b>Not contact traced</b> | <b>Contact traced</b> | <b>Total</b> |
|------------------|-------------------|---------------------------|-----------------------|--------------|
| <b>Primary</b>   | Observed          | 6                         | 6                     | 12           |
|                  | Expected          | 3.909                     | 8.091                 | 12           |
|                  | Adjusted Residual | 1.351                     | -1.351                | -            |
|                  | P-value           | 0.177                     |                       | -            |
| <b>Secondary</b> | Observed          | 32                        | 68                    | 100          |
|                  | Expected          | 32.576                    | 67.424                | 100          |
|                  | Adjusted Residual | -0.25                     | 0.25                  | -            |
|                  | P-value           | 0.803                     |                       | -            |
| <b>Tertiary</b>  | Observed          | 5                         | 15                    | 20           |
|                  | Expected          | 6.515                     | 13.485                | 20           |
|                  | Adjusted Residual | -0.785                    | 0.785                 | -            |
|                  | P-value           | 0.433                     |                       | -            |
| <b>Total</b>     | Observed          | 43                        | 89                    | 132          |
|                  | Expected          | 43                        | 89                    | 132          |

**Table 11.** Post-hoc analysis for the chi-square test on the association between level of education and vaccination against COVID-19

| Education |                   | Not vaccinated | Vaccinated | Total |
|-----------|-------------------|----------------|------------|-------|
| Primary   | Observed          | 87             | 78         | 165   |
|           | Expected          | 86.429         | 78.571     | 165   |
|           | Adjusted Residual | 0.097          | -0.097     | -     |
|           | P-value           | 0.922          |            | -     |
| Secondary | Observed          | 337            | 357        | 694   |
|           | Expected          | 363.524        | 330.476    | 694   |
|           | Adjusted Residual | -3.612         | 3.612      | -     |
|           | P-value           | <0.001         |            | -     |
| Tertiary  | Observed          | 104            | 45         | 149   |
|           | Expected          | 78.048         | 70.952     | 149   |
|           | Adjusted Residual | 4.611          | -4.611     | -     |
|           | P-value           | <0.001         |            | -     |
| Total     | Observed          | 528            | 480        | 1008  |
|           | Expected          | 528            | 480        | 1008  |

### 3.4 Demographic structure of the population targeted by screening and the yield of screening across strata

The composition shows several significant results regarding the screening outcomes in different age groups and genders. In both genders the age among 18-19 and 20-24 years have reported no positive screening results (**Table 12**).

However, the proportion of females in the whole population, females (1.73%) were higher than males (1.4%) in the 18-19 age group, similarly, the males are higher in the age group (20-24) (**Table 12**).

The highest percentage of positive screening results generally found in females (22.41%) were in the age group 50-54 comparatively with all age groups. Alternatively, the males (27.78%) found highest positive screening results in the age group of 60-64. Perhaps, the highest proportion in the whole population was observed in the participants of the age groups was 50-54,60-64,65-69, which is above 10% (**Table 12**).

Among the older adults, the positive screening was observed in the age group of 70-74 in females (18.97%) and for males (11.11%) was observed positive screening in between 75-79) (**Table 12**).

The distribution of the population targeted by screening and the yield of screening across demographic strata are summarized in (**Figure 2**). The majority of screening detected dSVIs (59.2%) were observed among persons less than 65 years old.

**Table 12.** Demographic composition of the studied and the target population of the screening for visual acuity loss with the yield of screening across strata

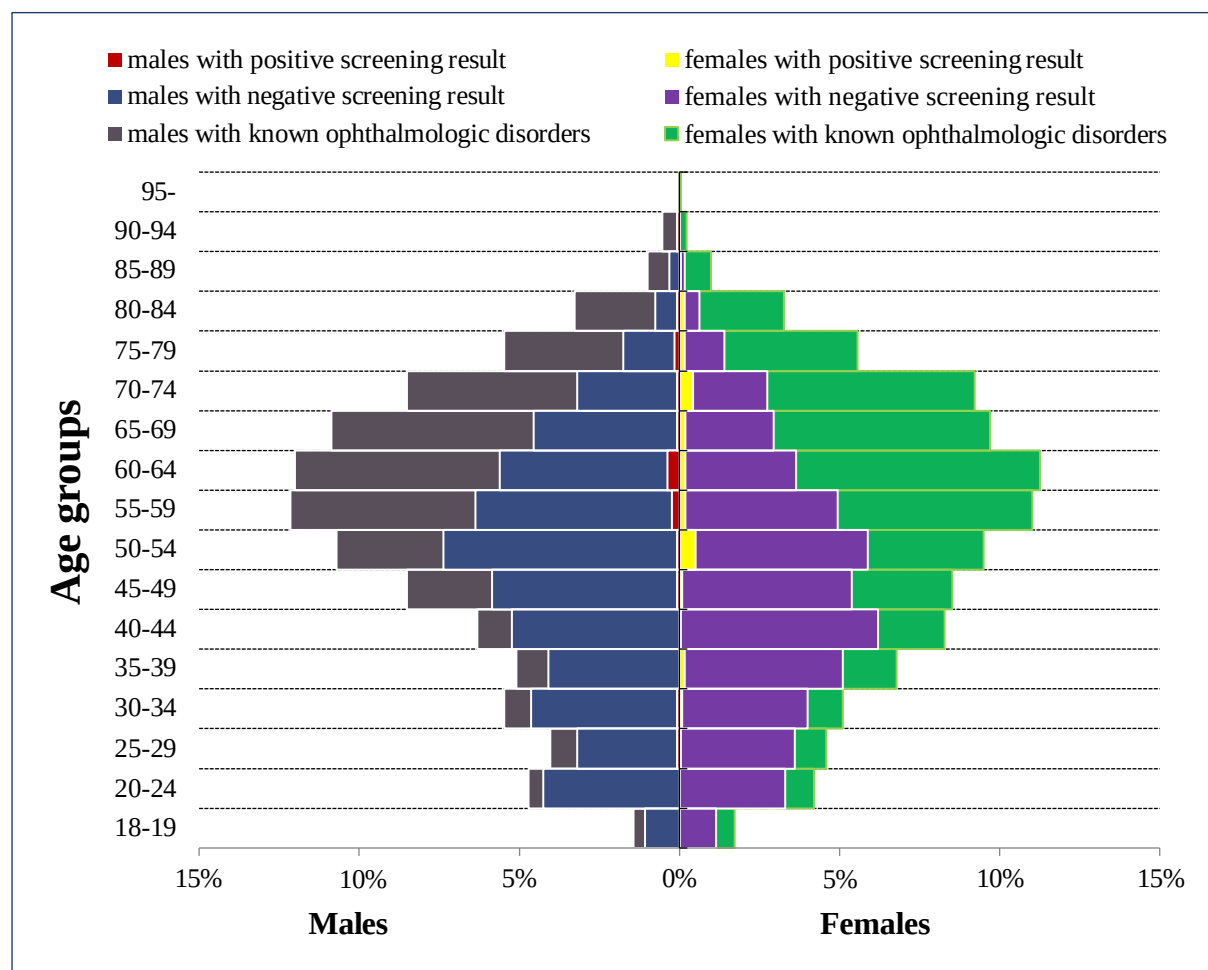
| age groups | whole population |              | target group of the screening |              | positive screening results |             |
|------------|------------------|--------------|-------------------------------|--------------|----------------------------|-------------|
|            | Males            | Females      | Males                         | Females      | Males                      | Females     |
| 18-19      | 19 (1.44%)       | 44 (1.73%)   | 14 (1.82%)                    | 29 (2.23%)   | 0 (0%)                     | 0 (0%)      |
| 20-24      | 62 (4.71%)       | 107 (4.20%)  | 56 (7.29%)                    | 84 (6.45%)   | 0 (0%)                     | 0 (0%)      |
| 25-29      | 53 (4.02%)       | 117 (4.59%)  | 42 (5.47%)                    | 92 (7.07%)   | 1 (5.56%)                  | 1 (1.72%)   |
| 30-34      | 72 (5.47%)       | 130 (5.10%)  | 61 (7.94%)                    | 102 (7.83%)  | 1 (5.56%)                  | 2 (3.45%)   |
| 35-39      | 67 (5.09%)       | 173 (6.79%)  | 54 (7.03%)                    | 130 (9.98%)  | 0 (0%)                     | 4 (6.90%)   |
| 40-44      | 83 (6.30%)       | 211 (8.28%)  | 69 (8.98%)                    | 158 (12.14%) | 0 (0%)                     | 1 (1.72%)   |
| 5-49       | 112 (8.50%)      | 217 (8.52%)  | 77 (10.03%)                   | 137 (10.52%) | 1 (5.56%)                  | 2 (3.45%)   |
| 50-54      | 141 (10.71%)     | 242 (9.50%)  | 97 (12.63%)                   | 150 (11.52%) | 1 (5.56%)                  | 13 (22.41%) |
| 55-59      | 160 (12.15%)     | 281 (11.03%) | 84 (10.94%)                   | 126 (9.68%)  | 3 (16.67%)                 | 5 (8.62%)   |
| 60-64      | 158 (12.00%)     | 287 (11.26%) | 74 (9.64%)                    | 93 (7.14%)   | 5 (27.78%)                 | 5 (8.62%)   |
| 65-69      | 143 (10.86%)     | 247 (9.69%)  | 60 (7.81%)                    | 75 (5.76%)   | 1 (5.56%)                  | 5 (8.62%)   |
| 70-74      | 112 (8.50%)      | 235 (9.22%)  | 42 (5.47%)                    | 70 (5.38%)   | 1 (5.56%)                  | 11 (18.97%) |
| 75-79      | 72 (5.47%)       | 142 (5.57%)  | 23 (2.99%)                    | 36 (2.76%)   | 2 (11.11%)                 | 4 (6.90%)   |
| 80-84      | 43 (3.26%)       | 83 (3.26%)   | 10 (1.30%)                    | 16 (1.23%)   | 1 (5.56%)                  | 4 (6.90%)   |
| 85-89      | 13 (0.99%)       | 25 (0.98%)   | 4 (0.52%)                     | 4 (0.31%)    | 0 (0%)                     | 1 (1.72%)   |
| 90-94      | 7 (0.53%)        | 6 (0.24%)    | 1 (0.13%)                     | 0 (0%)       | 1 (5.56%)                  | 0 (0%)      |
| 95-99      | 0 (0%)           | 1 (0.04%)    | 0 (0%)                        | 0 (0%)       | 0 (0%)                     | 0 (0%)      |
| Total      | 1317 (100%)      | 2548 (100%)  | 768 (100%)                    | 1302 (100%)  | 18 (100%)                  | 58 (100%)   |

### 3.5 Factors correlated to visual acuity in the entire target group and in the subgroup above 65 years by multivariate linear regression models

In multivariate linear regression analyses, female sex ( $b=1.27$ , 95% CI: 0.35; 2.18), age ( $b= 0.15$ , 95% CI: 0.12; 0.19), and Roma ethnicity ( $b= 2.60$ , 95% CI: 1.22; 3.97) were found to be significant risk factors for c VAL. Higher than primary school ( $b_{\text{secondary school without graduation}} = -2.06$ , 95% CI: -3.64; -0.47; and  $b_{\text{secondary school with graduation}} = -2.08$ , 95% CI: -3.65; -0.51) and employment ( $b: -1.33$ , 95% CI: -2.25; -0.40) were significant protective factors. Properly treated diabetes mellitus ( $b= -2.84$ , 95% CI: -5.08; -0.60) also proved protective in multivariate analysis. (**Table 13**)

In the age group above 65 years of age, female sex ( $b = 3.85$ , 95% CI: 0.50; 7.20), age ( $b = 0.39$ , 95% CI: 0.10; 0.67), Roma ethnicity ( $b = 24.79$ , 95% CI: 13.83; 35.76), and untreated diabetes ( $b = 7.30$ , 95% CI: 1.29; 13.31) were associated with cVAL. (**Table 13**)

**Figure 2. Population demographics and screening yield variation strata**



### 3.6 Associations between demographic factors, health behaviors and COVID-19 related epidemic measures: a univariate analysis

The univariate testing showed that there was no inequality in relation to sex and alcohol intake. Each outcome varied by age group. Persons at least 70 years old were less infected and less tested, but more vaccination occurred. In the survey, the primary educated proved to be less infected, and less tested. While the tertiary educated were more tested and vaccinated. Employed adults were more infected, more tested, but less vaccinated. Vaccination was less intense among smokers. Persons with chronic disease were less tested, more traced, and more vaccinated. The BMI was higher among vaccinated than among not vaccinated. (**Table 14**)

**Table 13.** Multivariate linear regression analysis indicators affecting visual acuity in the entire group and subgroup of above 65 years.

| Influencing factors |                                     | Adults (18+ years of age) | Above 65 years of age |
|---------------------|-------------------------------------|---------------------------|-----------------------|
| Sex                 | Male                                | 0 (reference)             | 0 (reference)         |
|                     | Female                              | 1.27 [ 0.35; 2.18]        | 3.85 [ 0.5; 7.2]      |
| Age                 | Mean ( $\pm$ SD)                    | 0.15 [ 0.12; 0.19]        | 0.39 [ 0.1; 0.67]     |
| Education           | Non-completed primary school        | 0 (reference)             | 0 (reference)         |
|                     | Completed primary school            | 0.45 [ -1.03; 1.94]       | 1.15 [ -3.83; 6.12]   |
|                     | Secondary school without graduation | -2.06 [ -3.64; -0.47]     | -2.58 [ -8.76; 3.59]  |
|                     | Secondary school with graduation    | -2.08 [ -3.65; -0.51]     | -1.22 [ -6.94; 4.51]  |
|                     | Higher education                    | -1.82 [ -3.89; 0.25]      | -0.24 [ -7.91; 7.42]  |
| Employment          | Unemployed                          | 0 (reference)             | ---                   |
|                     | Employed                            | -1.33 [ -2.25; -0.4]      | Nc                    |
| Ethnicity           | non-Roma                            | 1 (reference)             | 1 (reference)         |
|                     | Roma                                | 2.6 [1.22; 3.97]          | 24.79 [ 13.83; 35.76] |
| Hypertension        | Normotensive                        | 0 (reference)             | 0 (reference)         |
|                     | Untreated hypertension              | 0.31 [ -1.08; 1.7]        | 0.76 [ -5.79; 7.31]   |
|                     | Insufficiently treated hypertension | 0.36 [ -0.92; 1.64]       | 1.17 [ -4.46; 6.8]    |
|                     | Properly treated hypertension       | -0.6 [ -1.87; 0.68]       | 0.02 [ -5.7; 5.74]    |
| Diabetes            | Normoglycemic                       | 0 (reference)             | 0 (reference)         |
|                     | Untreated diabetes                  | 0.68 [ -1.61; 2.98]       | 7.3 [1.29; 13.31]     |
|                     | Insufficiently treated diabetes     | 0.37 [ -1.45; 2.19]       | 1.73 [ -3.06; 6.51]   |
|                     | Properly treated diabetes           | -2.84 [ -5.08; -0.6]      | -0.8 [ -6.38; 4.78]   |

\* adjusted linear regression coefficients with corresponding [95% CIs]; nc: not included in the model.

**Table 14.** Prevalence of SARS-CoV-2 infection and the implementation of epidemiological measures by sociodemographic status, lifestyle and chronic disease occurrence in the sample investigated by the ISSP 2021 survey

|                  |               | Distribution   | Infected*                     | P***  | Testing*                      | P***   | Traced*                           | P***  | Vaccinated*                   | P***   |
|------------------|---------------|----------------|-------------------------------|-------|-------------------------------|--------|-----------------------------------|-------|-------------------------------|--------|
| Age              | 18-40y        | 270 (26.8%)    | 32/262 (12.2%)                | 0.006 | 85/270 (31.5%)                | <0.001 | 18/32 (56,3%)                     | 0.031 | 77/270 (28.5%)                | <0.001 |
|                  | 41-70y        | 606 (60.1%)    | 82/590 (13.9%)                |       | 238/606 (39.3%)               |        | 67/82 (81,7%)                     |       | 338/606 (55.8%)               |        |
|                  | 71y-          | 132 (13.1%)    | 5/130 (3.8%)                  |       | 17/132 (12.9%)                |        | 4/5 (80%)                         |       | 113/132 (85.6%)               |        |
| Sex              | Female        | 596 (59.1%)    | 67/582 (11.5%)                | 0.483 | 205/596 (34.4%)               | 0.591  | 51/67 (76,1%)                     | 0.597 | 324/596 (54.4%)               | 0.130  |
|                  | Male          | 412 (40.9%)    | 52/400 (13%)                  |       | 135/412 (32.8%)               |        | 38/52 (73,1%)                     |       | 204/412 (49.5%)               |        |
| Education        | Primary       | 165 (16.4%)    | 9/161 (5.6%)                  | 0.021 | 26/165 (15.8%)                | <0.001 | 6/9 (66,7%)                       | 0.324 | 87/165 (52.7%)                | <0.001 |
|                  | Secondary     | 694 (68.8%)    | 90/675 (13.3%)                |       | 241/694 (34.7%)               |        | 68/90 (75,6%)                     |       | 337/694 (48.6%)               |        |
|                  | Tertiary      | 149 (14.8%)    | 20/146 (13.7%)                |       | 73/149 (49%)                  |        | 15/20 (75%)                       |       | 104/149 (69.8%)               |        |
| Employment       | Employed      | 657 (65.2%)    | 90/638 (14.1%)                | 0.007 | 269/657 (40.9%)               | <0.001 | 69/90 (76,7%)                     | 0.279 | 312/657 (47.5%)               | <0.001 |
|                  | Not-employed  | 349 (34.6%)    | 28/342 (8.2%)                 |       | 70/349 (20.1%)                |        | 19/28 (67,9%)                     |       | 216/349 (61.9%)               |        |
|                  | Missing       | 2 (0.2%)       | 1/2 (50%)                     |       | 1/2 (50%)                     |        | 1/1 (100%)                        |       | 0/2 (0%)                      |        |
| Smoking          | Regular       | 281 (27.9%)    | 34/278 (12.2%)                | 0.932 | 96/281 (34.2%)                | 0.764  | 27/34 (79,4%)                     | 0.943 | 112/281 (39.9%)               | <0.001 |
|                  | Not smoker    | 726 (72%)      | 85/703 (12.1%)                |       | 244/726 (33.6%)               |        | 62/85 (72,9%)                     |       | 416/726 (57.3%)               |        |
|                  | Missing       | 1 (0.1%)       | 0/1 (0%)                      |       | 0/1 (0%)                      |        | ---                               |       | 0/1 (0%)                      |        |
| Alcohol drinking | Regular       | 129 (12.8%)    | 17/126 (13.5%)                | 0.770 | 39/129 (30.2%)                | 0.394  | 13/17 (76,5%)                     | 0.760 | 61/129 (47.3%)                | 0.149  |
|                  | Not regular   | 877 (87%)      | 102/854 (11.9%)               |       | 301/877 (34.3%)               |        | 76/102 (74,5%)                    |       | 467/877 (53.2%)               |        |
|                  | Missing       | 2 (0.2%)       | 0/2 (0%)                      |       | 0/2 (0%)                      |        | ---                               |       | 0/2 (0%)                      |        |
| Chronic disease  | Present       | 274 (27.2%)    | 30/265 (11.3%)                | 0.835 | 74/274 (27%)                  | 0.017  | 28/30 (93,3%)                     | 0.036 | 203/274 (74.1%)               | <0.001 |
|                  | Absent        | 733 (72.7%)    | 89/716 (12.4%)                |       | 266/733 (36.3%)               |        | 61/89 (68,5%)                     |       | 325/733 (44.3%)               |        |
|                  | Missing       | 1 (0.1%)       | 0/1 (0%)                      |       | 0/1 (0%)                      |        | ---                               |       | 0/1 (0%)                      |        |
| BMI**            | Mean $\pm$ SD | 26.1 $\pm$ 4.5 | 26.1 $\pm$ 4.6/26.0 $\pm$ 4.5 | 0.832 | 25.8 $\pm$ 4.5/26.2 $\pm$ 4.5 | 0.229  | 26,64 $\pm$ 4,85/24,73 $\pm$ 3,73 | 0.431 | 26.4 $\pm$ 4.3/25.7 $\pm$ 4.6 | 0.008  |
| Total            |               | 1008 (100%)    | 119/982 (12.1%)               |       | 340/1008 (33.7%)              |        | 89/119 (74.8%)                    |       | 528/1008 (52.4%)              |        |

\* number of cases with positive outcome/total number of cases (percentage of positive outcome). \*\* mean  $\pm$  SD among outcome positives/mean  $\pm$  SD among outcome negatives. \*\*\* chi-square test, and t-test for BMI. # infections confirmed by laboratory findings.

### 3.7 Factors associated with visual impairment (with less than 0.5 visual acuity) in the entire target group and in the subgroup above 65 years of age by multivariate logistic regression models

Examining the entire target group using multivariate logistic regression analysis, we found that secondary level education compared to primary level education was a significant protective factor against dSVI (OR= 0.35, 95% CI: 0.13; 0.93. However, age (OR=1.06, 95% CI: 1.04; 1.06) and Roma ethnicity (OR=2.80, 95% CI: 1.41; 5.55) were significant risk factors (**Table 15**).

**Table 15.** Investigating visual impairment (visual acuity < 0.5) and its associations by multivariate logistic regression analysis

| Influencing factors |                                     | Adults (18+ years of age) | Above 65 years of age     |
|---------------------|-------------------------------------|---------------------------|---------------------------|
| Sex                 | Male                                | 1 (reference)             | 1 (reference)             |
|                     | Female                              | 1.75 [0.98; 3.14]         | 2.56 [0.91; 7.16]         |
| Age                 | Year                                | <b>1.06 [1.04; 1.08]</b>  | <b>1.1 [1.03; 1.18]</b>   |
| Education           | Non-completed primary school        | 1 (reference)             | 1 (reference)             |
|                     | Completed primary school            | 1.14 [0.59; 2.19]         | 1.16 [0.38; 3.56]         |
|                     | Secondary school without graduation | 0.61 [0.25; 1.49]         | 0.3 [0.03; 3.10]          |
|                     | Secondary school with graduation    | 0.35 [0.13; 0.93]         | 0.51 [0.10; 2.44]         |
|                     | Higher education                    | 1.18 [0.41; 3.37]         | 1.7 [0.33; 8.83]          |
| Employment          | Unemployed                          | 1 (reference)             | ---                       |
|                     | Employed                            | 0.57 [0.30; 1.12]         | Nc                        |
| Ethnicity           | Non-Roma                            | 1 (reference)             | 1 (reference)             |
|                     | Roma                                | <b>2.80 [1.41; 5.55]</b>  | <b>7.81 [1.36; 44.68]</b> |
| Hypertension        | Normotensive                        | 1 (reference)             | 1 (reference)             |
|                     | Untreated hypertension              | 0.50 [0.20; 1.26]         | 0.96 [0.08; 12.3]         |
|                     | Insufficiently treated hypertension | 0.80 [0.40; 1.6]          | 2.56 [0.31; 21.34]        |
|                     | Properly treated hypertension       | 0.71 [0.35; 1.45]         | 2.48 [0.29; 21.00]        |
| Diabetes mellitus   | Normoglycemic                       | 1 (reference)             | 1 (reference)             |
|                     | Untreated diabetes                  | 1.16 [0.43; 3.12]         | 2.03 [0.56; 7.42]         |
|                     | Insufficiently treated diabetes     | 1.17 [0.52; 2.64]         | 1.34 [0.39; 4.63]         |
|                     | Properly treated diabetes           | 0.18 [0.02; 1.32]         | 0.34 [0.04; 2.87]         |

\*adjusted odds ratios with corresponding [95%CI]; nc: not included in the model

In the subgroup of patients older than 65 years, age (OR=1.10, 95% CI: 1.03; 1.18) and Roma ethnicity (OR=7.81, 95% CI: 1.36; 44.68) were found to be significant risk factors for dSVI (Table 15).

**Table 16.** Association between socio-demographic and clinical characteristics with the visual impairment among adults not above 65 by multivariate linear and logistic regression models

| Influencing factors |                                     | Adjusted linear regression coefficients* | Adjusted odds ratios*    |
|---------------------|-------------------------------------|------------------------------------------|--------------------------|
| Sex                 | Male                                | 0 (reference)                            | 1 (reference)            |
|                     | Female                              | 0,72 (-0,16; 1,59)                       | 1,37 (0,66; 2,81)        |
| Age                 | Mean ( $\pm$ SD)                    | <b>0,12 (0,08; 0,16)</b>                 | <b>1,08 (1,04; 1,12)</b> |
| Education           | Non-completed primary school        | 0 (reference)                            | 1 (reference)            |
|                     | Completed primary school            | 0,64 (-0,81; 2,08)                       | 1,36 (0,57; 3,24)        |
|                     | Secondary school without graduation | -1,37 (-2,88; 0,14)                      | 0,75 (0,26; 2,18)        |
|                     | Secondary school with graduation    | <b>1,72 (-3,23; -0,22)</b>               | 0,32 (0,09; 1,14)        |
|                     | Higher education                    | -1,61 (-3,58; 0,36)                      | 1,02 (0,24; 4,34)        |
| Employment          | Unemployed                          | 0 (reference)                            | 1 (reference)            |
|                     | Employed                            | <b>-1,15 (-1,99; -0,31)</b>              | 0,52 (0,26; 1,02)        |
| Ethnicity           | Non-Roma                            | 0 (reference)                            | 1 (reference)            |
|                     | Roma                                | <b>2,14 (0,91; 3,36)</b>                 | <b>2,3 (1,08; 4,93)</b>  |
| Hypertension        | Normotensive                        | 0 (reference)                            | 1 (reference)            |
|                     | Untreated hypertension              | 0,38 (-0,92; 1,69)                       | 0,51 (0,18; 1,47)        |
|                     | Insufficiently treated hypertension | 0,31 (-0,91; 1,54)                       | 0,58 (0,25; 1,34)        |
|                     | Properly treated hypertension       | -0,59 (-1,8; 0,62)                       | 0,47 (0,19; 1,17)        |
| Diabetes            | Normoglycemic                       | 0 (reference)                            | 1 (reference)            |
|                     | Untreated diabetes                  | -2,29 (-4,71; 0,12)                      | 0,41 (0,05; 3,11)        |
|                     | Insufficiently treated diabetes     | -0,03 (-1,94; 1,88)                      | 1,09 (0,35; 3,4)         |
|                     | Properly treated diabetes           | <b>-3,03 (-5,46; -0,6)</b>               | Nc                       |

\* with corresponding (95% CIs; ) nc: not computable

The analysis of adjusted linear regression and adjusted odds ratio emphasizes the significant influential roles of factors such as age, secondary education with graduation, employment and Roma ethnicity and diabetes in shaping the probability of experiencing visual impairment

among individuals who are less than 65 years. Particularly, effective diabetes management seems to have a positive impact on decreasing the risk of visual impairment (**Table 16**).

**Table 17.** Associations with sociodemographic and lifestyle factors and the presence of chronic disease with test-confirmed SARS-CoV-2 infection, testing for SARS-CoV-2 infection, contact tracing, and SARS-CoV-2 vaccination according to multivariable logistic regression analyses (adjusted odds ratios with 95% confidence intervals)

| Influencing factors |                                         | Infection             | Testing               | Tracing*               | Vaccination             |
|---------------------|-----------------------------------------|-----------------------|-----------------------|------------------------|-------------------------|
| Sex                 | Male / Female                           | 1.12<br>(0.73 - 1.73) | 1.04<br>(0.77 - 1.42) | 0.50<br>(0.20 - 1.26)  | 0.85<br>(0.62 - 1.16)   |
| Age (years)         | 41-70 / 18-40                           | 1.15<br>(0.71 - 1.84) | 1.53<br>(1.10 - 2.13) | 3.33<br>(1.17 - 9.45)  | 2.94<br>(2.09 - 4.15)   |
|                     | 71+ / 18-40                             | 0.37<br>(0.12 - 1.10) | 0.70<br>(0.36 - 1.37) | 4.60<br>(0.45 - 46.89) | 14.52<br>(7.33 - 28.77) |
| Education           | Secondary / Primary                     | 2.00<br>(0.94 - 4.25) | 1.93<br>(1.20 - 3.13) | 3.95<br>(0.96 - 16.24) | 1.69<br>(1.08 - 2.63)   |
|                     | Tertiary / Primary                      | 2.11<br>(0.88 - 5.06) | 3.19<br>(1.81 - 5.63) | 4.73<br>(0.85 - 26.37) | 4.36<br>(2.46 - 7.73)   |
| Employment          | Employed / Not-employed                 | 1.43<br>(0.84 - 2.43) | 2.06<br>(1.42 - 3.00) | 4.58<br>(1.38 - 15.22) | 1.25<br>(0.87 - 1.79)   |
| Drinking Alcohol    | Regular drinking / Not regular drinking | 1.17<br>(0.65 - 2.11) | 0.83<br>(0.53 - 1.28) | 1.08<br>(0.33 - 3.46)  | 0.90<br>(0.58 - 1.40)   |
| Smoking             | Regular smoking / Not regular Smoking   | 0.87<br>(0.55 - 1.36) | 0.99<br>(0.72 - 1.35) | 0.96<br>(0.37 - 2.50)  | 0.60<br>(0.44 - 0.83)   |
| BMI                 | kg/m <sup>2</sup>                       | 1.00<br>(0.96 - 1.05) | 0.98<br>(0.95 - 1.02) | 0.99<br>(0.90 - 1.09)  | 0.99<br>(0.96 - 1.03)   |
| Chronic Disease     | Present / Absent                        | 1.43<br>(0.84 - 2.41) | 1.17<br>(0.80 - 1.71) | 5.92<br>(1.56 - 22.47) | 2.58<br>(1.75 - 3.80)   |

\* among test positive infected.

Positive correlation was observed between age groups and vaccination frequency ( $aOR_{41-70y} = 2.94$ , 95% CI 2.09–4.15;  $aOR_{71+y} = 14.52$ , 95% CI 7.33–28.77). Higher than primary education ( $aOR_{secondary} = 1.69$ , 95% CI 1.08–2.63;  $aOR_{tertiary} = 4.36$ , 95% CI 2.46–7.73) and the presence of a chronic disease ( $aOR = 2.58$ , 95% CI 1.75–3.80) positively impacted vaccination. Regular smoking was inversely correlated with vaccination ( $aOR = 0.60$ ; 95% CI 0.44–0.83) (**Table 17**).

### 3.8. Factors influencing socio-demographics, lifestyle, and COVID-19 epidemiologic measures: a multivariable analysis

According to the multivariable model, the occurrence of test-confirmed SARS-CoV-2 infection was not influenced by the investigated explanatory variables.

Testing was more frequent among middle-aged adults (aOR = 1.53, 95% CI 1.10–2.13) and employed adults (aOR = 2.06, 95% CI 1.42–3.00) and was more frequent among adults with a higher education than those with a primary education (aOR<sub>secondary</sub> = 1.93, 95% CI 1.20–3.13; aOR<sub>tertiary</sub> = 3.19, 95% CI 1.81–5.63) (**Table 17**).

Contact tracing was more frequently implemented among middle-aged (aOR<sub>41–70y</sub> = 3.33, 95% CI 1.17–9.45) and employed (aOR = 4.58, 95% CI 1.38–15.22) adults and those with chronic diseases (aOR = 5.92, 95% CI 1.56–22.47) (**Table 17**).

## **4. Discussion**

### **4.1 Main findings of the visual acuity survey**

#### **Proportion of the target screening group in the whole population**

According to our investigation, 53.6% (95% CI: 52.0–55.1) of the adults (for males 58.3%, 95% CI: 55.7–61.0; for females 51.1% 95% CI: 49.2–53.0) and 30.2% (95% CI: 27.5–32.9) of the 65+ adults (for males 35.9%, 95% CI: 31.1–41.7; for females 27.2% 95% CI: 24.0–30.4) did not wear glasses or consult an ophthalmologist in a year.

To evaluate the observed proportions, prevalence of using glasses or consulting an ophthalmologist care was computed for other age groups. A former Hungarian survey reported a 24.0% of prevalence for the 20–64-year age group (50) which was lower, while another survey published 84.3% for the 50+ year age group (51) which was higher than the corresponding values observed in our investigation (36.9% and 59.8% respectively) (90).

In the Abruzzo region of Italy, the prevalence of known visual problems among individuals aged above 50 (44%) is less than the finding in our research prevalence of (59.8%). In the UK, 88% of people aged 75 or older reported owned glasses, which corresponds to the similar prevalence in our sample (76%) (91). The prevalence of use of glasses is 92.4% in the USA, among Medicare beneficiaries above 65 years of age which is above our observation (69.8%) (92). Our observation (53.5%) was much higher than that in India among (29.5%) the 40+ population. Overall, there is a wide range of country level variability in the proportion of the target screening group, and our sample cannot be considered extreme.

#### **Yield of the screening**

The yield of screening for dSVI in the better eye among adults aged 18 years and among elderly individuals at least 65 years old was estimated to be 3.7% (95% C.I: 2.9- 4.5); for males and

(2.3%, 95% C.I: 1.3 -3.4); for females: 4.5%, 95% C.I: 3.3 – 5.6). and 9.1%, 95% C.I: 6.0 - 12.1; for males 4.3%, 95% C.I: 0.9 -7.6; for females 12.4%, 95% C.I: 7.9 – 17.0) respectively.

The prevalence of dSVI was 5.6%, 3.8%, and 5.4% in Finland among adults 30+ adults (93) and in the UK among 65+ adults (91), and in Sweden among 70+ adults (94) respectively. The corresponding values in the target group of our investigation were 4.2%, 9.1% and 12.1% respectively. In low- and middle-income countries the prevalence of dSVI was 1.9%,

11.7% and 1.8% in Rwanda among 17-39, among 40+ (95) and in India among 15-49 (96) respectively, the corresponding values in the target group of our investigation were 1.4%, 4.8% and 1.2% respectively.

The screening yield among adults without glasses or ophthalmologic consultation was higher in our sample than the prevalence of dSVI in Sweden and in the UK. It is highly probable that a significant proportion of dSVI is detectable by population-based screening in Hungary.

According to the representative Hungarian survey among 50+ individuals, the prevalence of dSVI was 14.5% (50). Because the yield of screening was 6.5% in this age group in our investigation, 45% of the cases are not detected by the usual ophthalmologic care and can be detected by organized screening in the deprived Hungarian population.

### **Influencing factors for screening positivity**

Our results demonstrated the sociodemographic inequality of visual acuity loss. Visual acuity loss of any degree is associated with older age, female sex, and Roma ethnicity. Higher levels of education, employment, and well-treated diabetes were found to be protective factors. The risk factor role of higher age and Roma ethnicity was also observed for the outcome of dSVI. A similar risk factor pattern was observed for elderly individuals over 65 years of age, although the role of employment could not be studied, and the role of education was not significant in this age group.

These observations are in agreement with the known risk factors for visual acuity loss. Surveys in the US, Japan, and Mexico suggested that older age is associated with higher odds of visual impairment (97-100). Female sex was an independent risk factor for low vision in studies carried out in Singapore (101,102). The lower risk among more educated individuals has been convincingly demonstrated by a series of reports (99,103,104). The protective role of employment was determined in Norway and in South Korea (105,106). The risk factor role of Roma ethnicity was explored in a former Hungarian study (107). A high risk among indigenous populations was also detected in Brazil (108). The protective role of proper care of diabetes mellitus was demonstrated in the United States (109) and Iran (110) as well.

### **4.2 Main findings of COVID-19 survey**

The SARS-CoV-2 infection rate in our study was 12%, slightly higher than the ECDC reported indicators for Hungary (cumulative rate of infection: 8.2%), showing that our sample was not fully representative of Hungary.

The distribution of infections across the studied strata was not uneven in our investigation.

The published stronger vulnerability of women (111-114), overweight persons (115,116,117), smokers (118,119), regular alcohol drinkers (118,119), employed (120,121,122), persons with low education (123,124) and patients with chronic diseases (120,125,126,127) was not observed in our investigation. The lack of these associations can be at least partly attributed to the low statistical power in our analysis.

The testing coverage of 33.7% observed in our survey was lower than in other high-income countries (128,129,130) although these reference data were reported considerably earlier than the ISSP survey. However, the Hungarian testing coverage was higher than that in Brazil (131) and India (132). Unfortunately, Hungary ceased reporting testing frequency on 1 January 2021. Nevertheless, by the time of the ISSP survey the number of people tested was higher than the number of citizens in Europe. Therefore, the Hungarian testing frequency is considered to be below the European average.

Middle-aged (130,133,134) employed (130,133-136) and highly educated individuals (134,137) most frequently received testing, consistent with published international experience (138). It is the consequence of the adaptation of the high-risk target groups' definition for screening group by the WHO recommendations (139). The influencing impact of being overweight, smoking, and alcohol consumption on SARS-CoV-2 testing (137) was not observed in our sample. Furthermore, we found no association between chronic diseases (140) and SARS-CoV-2 testing was not observed in our sample.

Altogether, the low testing rates were accompanied by a relatively high infection rate in Hungary. This gap could contribute to the higher-than-expected mortality rate. Moreover, this problem could be more pronounced among less educated, unemployed, and non-middle-aged adults.

The coverage of contact tracing among infected individuals was 74.8% in our survey, far lower than that reported in Spain, Hong Kong, and India (141-143) but similar to that reported in Catalonia (144). The low incidence of contact tracing could be attributed to the failure of laboratories to communicate positive test results to public health authorities, the lack of contact information provided in the notifications, the refusal of patients to participate, and the lack of contact tracing for patients admitted to the hospital. Although the number of contact tracing staff increased enormously in Hungary, involving police and municipalities and governmental department employees, more contact tracers should have been employed. A contact tracing team 1.34 times larger than the one used would have been beneficial as it could ensure reaching all infected instead of just 74.8% of them.

The inequalities in contact tracing implementation in Hungary were comparable to those in

other countries; contact tracing was more prevalent among employed adults (75,76,144,145,146), middle-aged individuals (75,76), older adults (138,147), highly educated individuals (148), and patients with chronic disease (147). No association between smoking, high BMI, and regular alcohol consumption with contact tracing was observed. As contact tracing is crucial in preventing infection spread, incomplete contact tracing may have contributed to excess mortality. This impact could be more profound among non-middle-aged, unemployed, and primary-educated adults, and those without chronic disease.

The vaccination rate in our study was 52.4% (95% CI: 49.3–55.5), slightly higher than the ECDC-reported indicators for Hungary (50.9%) and significantly higher than that reported in the EU (44%). The high vaccination rate was the main positive characteristic of Hungarian epidemic control at the time of the ISSP survey. The mass vaccination program started in January 2021; thus, vaccination likely reduced COVID-19-related mortality in Hungary before the ISSP survey was conducted. Therefore, the effect of infrequent testing and poor contact tracing practices is likely more serious than suggested by the 11,837 rate-corrected excess cases.

Middle-aged, older, employed adults, those with higher education [148,149,150], and those with chronic diseases (147, 151,152) were more likely to be vaccinated in our study sample, similar to the findings of other studies. It has been demonstrated that being obese is a significant factor in the likelihood of adverse immune responses to SARS-CoV-2 vaccination (153,154); however, this observation is contrary to our findings. Regular smokers were considerably less likely to be vaccinated against SARS-CoV-2, consistent with other published studies (155,156).

### **4.3. Strengths and limitations**

#### **Strengths and limitations of visual acuity survey**

This investigation was a secondary data analysis on a dataset that was designed to evaluate the relative effectiveness of GPC compared to solo general medical practices (82). A fairly large dataset that provides adequate statistical power was utilized. On the other hand, we faced the obvious limitations of an investigation designed to not evaluate visual acuity loss screening. Namely, there is a lack of data on the pathological conditions behind visual acuity loss among screening-positive subjects and among persons who were not targeted by the screening because of their known ophthalmologic care. Additionally, the sample size of 65+ participants resulted in a very wide 95% CIs and the high probability of type 2 errors in

statistical inference. Altogether, using this design, we could estimate the yield of a population-based visual acuity loss screening in a setting that differs from the setting from which the recent recommendations originate and determine the high-risk groups where the screening is more effective.

### **Strengths and limitations of COVID-19 survey**

The data collection was organized by an ISSP team with decades of experience, and the data were inserted into the omnibus survey of an international project with high quality standards. Although each outcome was assessed by self-reporting, the participants were asked about their recent, 12 to 14 months' experiences regarding a very important issue. Therefore, significant recall bias was unlikely.

Males, middle-aged individuals, secondary-educated individuals, regular drinkers, and individuals with chronic diseases were underrepresented in the sample. Although the representativeness was not perfect, deviations were less than 10% apart from the proportion of secondary-educated (66.8% in the sample, 55.0% in the population).

The relatively small sample size prevented a more detailed analysis evaluating the role of potential influencing factors (more detailed socioeconomic and clinical indicators) and resulted in results with borderline significance. A more detailed investigation with a larger sample size is required to improve the interpretation of our study. All persons with infections were not identified in the survey due to the low testing activity. There were subjects with subclinical infection without perception of the infection. They were not tested because the test-based, organized screening program was restricted to selected high-risk populations (defined by occupation) in Hungary.

Additionally, it was directly quantified by the survey that there were persons with recognized symptoms but there was no test confirmation. Consequently, persons with infection confirmed by laboratory findings, who were considered as infected in our analyses, were composed of a subgroup of all infected persons.

## **4.4 Study implications**

### **Implications of visual acuity survey**

Because the known prevalence of dSVI is highly variable by country and social strata, screening focusing on people without known dSVI yields a highly variable number of subjects who could benefit from screening by the same dimensions. Therefore, the screening

recommendations should be tailored by monitoring for dSVI prevalence or by targeted surveys on the prevalence of dSVI. The lower the prevalence of known dSVI, the more important it would be to organize population-based, active screening.

On the other hand, unknown dSVI seems to be more prevalent among less affordable patients. It seems that people with a lower socioeconomic status could benefit more from the organized approach.

Considering the safe, accurate nature of the screening methods and the fact that the only significant resource need is the organization of population-based screening (calling for and investigating adults), the more screening is implemented into the regular general health check, the most advantageous the cost effectiveness of the screening.

Consequently, not the necessity but the implementation protocol of screening organizations should be the concern in less affordable countries and populations. In a less affordable setting, the affordable countries' practice, where screening is recommended despite the uncertainties of its benefits (45,47,157) should be followed by integrating visual acuity loss screening into the general health check approach to realize potential health gains. According to this Hungarian study, 45% of dSVI is screening-detectable in the 50+ population, and 59.2% of the screening-detectable cases are from less than 65-year-old adults.

### **Implications of COVID-19 survey**

The populations of unemployed and primary-educated people are 5.3 and 3 million, respectively, in Hungary. Converting the adjusted odds ratio into the adjusted risk ratio (158), the estimated number of people without contact tracing among unemployed individuals was 240,715, the number of unvaccinated primary-educated individuals was 1,076,541, and the numbers of primary-educated and unemployed individuals who did not receive testing were 647,828 and 1,332,869, respectively. Clearly, these missing interventions should be prevented.

Smokers' risk-taking behavior (159,155) and smokers believe that they are protected against the severe manifestation of COVID-19 infection (160) can be reflected in their lower vaccination rate.

The organization of vaccination should seriously consider the special needs of this vulnerable group because it is well-known that the consequences of COVID-19 infection are more serious among smokers than among non-smokers (161).

Patients with chronic disease provided with continuous care were not traced and vaccinated rigorously according to the guidelines, which is unacceptable from a quality management

viewpoint. While the less-than-complete vaccination coverage can be explained by the restricted availability of vaccines at the time of the survey, the lack of contact tracing is an obvious failure of epidemiological control.

Our findings suggest that more rigorous organization of epidemiological measures is needed. To establish better organization, more intensive monitoring is also needed. It is insufficient to monitor testing, infection rate, contact tracing, and vaccination rate by aggregated indicators. Detailed monitoring is required to identify high-risk groups receiving substandard care. The epidemiological measures of authorities, healthcare providers, and common people were on many occasions' desperate reactions to an exceptional challenge, which were based in many cases on expert opinion during the COVID-19 pandemic. Honestly, a lot of decisions lacked the usual evidence base (145). As the expert opinions relied on weak evidence and on uncertain quality data, it was inevitable that the lack of knowledge evolved the room for prevailing other interests from the political arena, economy, and mass media.

Expert opinions incorporated both insufficient scientific knowledge and the non-scientific influences. However, the nature of the epidemic urged interventions, which deeply intervened into the normal operations of the society. During the emergent situation where high-impact decisions and their consistent implementation were needed in spite of the fact that the evidence was insufficient, it was obvious that some decisions were not proper. Unfortunately, the inappropriateness of a decision could be perceived only after the manifestation of the consequences not intended. It was unavoidable to undertake the learning-by-doing approach (162,163). To improve our ability to realize the need for modification of a decision, more timely and detailed monitoring is required, which makes it possible to improve the effectiveness of the epidemiological control measures at any level.

## **5. Conclusions**

### **5.1 Conclusions for visual acuity survey**

International recommendations based on Western European and North American studies do not recommend organized screening for visual acuity loss in primary care. (1) According to our study among deprived Hungarian adults, the prevalence of unknown visual acuity loss of at least 0.5 is 3.7% and 9.1% in adults and in the above-65 population, respectively. (2) In this setting, male sex, employment, higher-than-primary education, and properly treated diabetes proved to be protective, while higher age, Roma ethnicity, and untreated hypertension were risk factors. (3) These results demonstrate that adults in Hungary could benefit from regular visual acuity screening. (4) The high rate of undiagnosed visual acuity loss in this population suggests that primary care should implement population-based screening among adults more rigorously, and the performance of general medical practices should be supported by regular monitoring of this service. Considering the significant disparities in healthcare access and the social status of the populations in countries like Hungary, which is not classified as high-income nations, the discouraging statement from USPTPF regarding visual acuity loss screening should not dissuade general practitioners from considering the organizing the population based visual acuity screening programs for visual acuity loss. Our observation of a higher risk of undiagnosed visual acuity loss among patients receiving inadequate care and experiencing relative deprivation, even within Hungary, support this conclusion.

### **5.2 Conclusions for COVID-19 Survey**

The survey was conducted during the third wave of the COVID-19 pandemic, when the mass vaccination started, and the pandemic control mainly relied on epidemiologic measures. (1) It was the first Hungarian study on person-reported experiences about epidemiological control measures. It was demonstrated that epidemiological measures were not provided for everybody in terms of testing, contact tracing and vaccination. (2) The socioeconomic or lifestyle-related inequalities in test-confirmed SARS-CoV-2 infections were not confirmed by this investigation in Hungary. However, the survey indicated that testing, contact tracing, and vaccination were seriously influenced by socioeconomic position and less influenced by

chronic disease prevalence and very minimally by lifestyle. (3) Considering that the socioeconomic inequalities in COVID-19-related deaths have been demonstrated convincingly in Hungary and that epidemic measures are obviously effective, the etiological role of socioeconomic inequalities in epidemic measure implementation likely generated socioeconomic inequality in COVID-19-related death rates. (4) Therefore, monitoring sensitively to the target group characteristics when implementing epidemic measures appears necessary in managing epidemiological measures, and socially adapted implementation can mitigate the health effects of the COVID-19 epidemic.

### **5.3 Common conclusions**

Different socioeconomic groups experienced disparities in levels of service provision in the respect of both investigated preventive services. Individuals with higher affordability were provided with better services, while those who were deprived received comparatively fewer services.

Monitoring of under-provision for visual acuity screening and epidemiological measures should be tailored and customized. Being able to identify small populations with inadequate provision is essential to prevent the under- provision of deprived populations. Since patients need based services are essential in healthcare to provide personalized and targeted care of individuals based on their unique requirements and medical conditions. These services should be designed to address specific patient needs, ensuring that their treatment and support are custom-tailored to their physical, emotional, and social wellbeing. By focusing on individualized care, healthcare providers can deliver more effective and efficient treatments, which ultimately lead to better patient outcomes and improved overall satisfaction with healthcare experience.

Our surveys demonstrated that cultural adapted services (healthcare practices, interventions that have been modified to meet the cultural preferences, beliefs, norms, values, of a specific community) are required to mitigate the reported inequalities and the derived general under-provision of preventive services. These adapted services could promote better communication, understanding, and trust between patients and healthcare providers. Such adaptations could foster a more inclusive and patient centered approach, ultimately leading to improved health outcomes and increased patient satisfaction.

## **6. New findings**

### **Prevalence of visual acuity loss in deprived target population**

Our survey confirmed, 53.6% of the adults (for males 58.3%, for females 51.1%) and 30.2% of the 65+ adults (for males 35.9%; for females 27.2%) did not wear glasses or consult an ophthalmologist in a year, which is the target group of the visual acuity loss screening. Visual acuity less than 0.5 could be detected in 3.7% of the target group and in 9.1% of adults over 65 years of age.

### **Yield of visual acuity loss screening in deprived population**

The yield of screening for dSVI in the better eye among adults aged 18 years for among males is 2.3% and for females is 4.5% and among elderly individuals for males is 4.3% and for females is 12.4%. There are 45% of the dSVI cases are not detected by the usual ophthalmologic care and can be detected by organized screening in the deprived Hungarian population. The majority of the screening detected dSVIs (59.2%) were observed among persons less than 65 years old.

### **Determinants of screening positivity correlated to visual acuity.**

Age (OR=1.06, 95% CI: 1.04; 1.06) and Roma ethnicity (OR=2.80, 95% CI: 1.41; 5.55) were significant risk factors.

In the subgroup of patients older than 65 years, age (OR=1.10, 95% CI: 1.03; 1.18) and Roma ethnicity (OR=7.81, 95% CI: 1.36; 44.68) were found to be significant risk factors for dSVI.

### **Determinants of screening positivity in visual impairment (with less than 0.5 visual acuity)**

Female sex (b=1.27, 95% CI: 0.35; 2.18), age (b= 0.15, 95% CI: 0.12; 0.19), and Roma ethnicity (b= 2.60, 95% CI: 1.22; 3.97) were found to be significant risk factors for c VAL. In the age group above 65 years of age, female sex (b = 3.85, 95% CI: 0.50; 7.20), age (b = 0.39, 95% CI: 0.10; 0.67), Roma ethnicity (b = 24.79, 95% CI: 13.83; 35.76), and untreated diabetes (b = 7.30, 95% CI: 1.29; 13.31) were associated with cVAL.

## **Prevalence's of patient experiences with COVID-19-related infection, testing, contact tracing, and vaccination.**

The survey used ISSP dataset reports the prevalence of test-confirmed SARS-CoV-2 infection was 12.1%. Among the participants of 1008, 33.7% underwent testing and 74.8 % of those infected participants were subjected to contact tracing. The vaccination coverage was 52.4%.

## **Impact of sociodemographic, lifestyle, and clinical factors on self-reported COVID-19 related epidemiologic measures**

In our investigation, the distribution of **test confirmed infections** (12.1%) among the studied groups was not disparate.

**Testing** (33.7%) was more commonly administered to middle-aged (aOR = 1.53, 95% CI 1.10–2.13), employed (aOR = 2.06, 95% CI 1.42–3.00) and highly educated individuals (aOR<sub>secondary</sub> = 1.93, 95% CI 1.20–3.13; aOR<sub>tertiary</sub> = 3.19, 95% CI 1.81–5.63).

Across diverse demographic groups, **contact tracing** (74.8 %) was more common among employed adults (aOR = 4.58, 95% CI 1.38–15.22), middle-aged individuals (aOR<sub>41–70y</sub> = 3.33, 95% CI 1.17–9.45) and patients with chronic disease (aOR = 5.92, 95% CI 1.56–22.47).

**Vaccination** rates (52.4%) were higher among middle-aged (aOR<sub>41–70y</sub> = 2.94, 95% CI 2.09–4.15;), older (aOR<sub>71+y</sub> = 14.52, 95% CI 7.33–28.77), those with higher education (aOR<sub>secondary</sub> = 1.69, 95% CI 1.08–2.63; aOR<sub>tertiary</sub> = 4.36, 95% CI 2.46–7.73) and individuals with chronic diseases (aOR = 2.58, 95% CI 1.75–3.80).

## **Implementation and impact of imperfect epidemiological control measures on excess mortality**

1. the high vaccination rate was a notable positive aspect of Hungarian epidemic control during the ISSP survey
2. the early vaccination program likely reduced to COVID-19 related deaths in Hungary before the ISSP survey (from 15 March to 30 May 2021), highlighting the potential seriousness of limited testing and contact tracing
3. Hungary reported 29,733 COVID-related deaths by May 2021. Compared to EU average, the risk of infection in Hungary was 1.14 times higher, the infection rate corrected death risk remained at 1.66 potentially contributing to 11,837 deaths due to distinct conditions impacting control measures and patient treatment.
4. contact tracing staff should be increased significantly, since employing a larger team could have reached more infected individuals (74.8% reached by the time of the ISSP survey)

**Recommendations to intensify epidemic control and prevent malpractice**

ISSP survey findings indicate the necessity for a more robust organization of epidemiological measures. To attain effective organization, more comprehensive monitoring is necessary. Relying solely on aggregated indicators for testing, tracing, vaccination, infection rate is insufficient.

In management of the epidemic, expert opinions were shaped by both inadequate scientific knowledge and non-scientific influences. So, detailed monitoring is crucial to identify high risk groups that may be receiving substandard care.

## **7. Summary**

### **7.1 Screening for Patients with Visual Acuity Loss in Primary Health Care: A Cross Sectional Study in a Deprived Hungarian Population**

#### **Background:**

Screening for visual acuity loss is not applied systematically because of uncertain recommendations based on observations from affordable countries. Our study aimed to evaluate the effectiveness of primary health care-based screening.

#### **Methods:**

A cross-sectional investigation was carried out among adults who did not wear glasses and did not visit an ophthalmologist in a year (N = 2070). The risk factor role of sociodemographic factors and the cardiometabolic status for hidden visual acuity loss was determined by multivariable linear regression models.

#### **Results:**

The prevalence of unknown visual acuity loss of at least 0.5 was 3.7% and 9.1% in adults and in the above-65 population. Female sex ( $b = 1.27$ , 95% CI: 0.35; 2.18), age ( $b = 0.15$ , 0.12; 0.19), and Roma ethnicity ( $b = 2.60$ , 95% CI: 1.22; 3.97) were significant risk factors. Higher than primary school ( $b_{\text{secondaryschoolwithoutgraduation}} = -2.06$ , 95% CI: -3.64; -0.47; and  $b_{\text{secondaryschoolwithgraduation}} = -2.08$ , 95% CI: -3.65; -0.51), employment ( $b = -1.33$ , 95% CI: -2.25; 0.40), and properly treated diabetes mellitus ( $b = -2.84$ , 95% CI: -5.08; -0.60) were protective factors. Above 65 years, female sex ( $b = 3.85$ , 95% CI: 0.50; 7.20), age ( $b = 0.39$ , 95% CI: 0.10; 0.67), Roma ethnicity ( $b = 24.79$ , 95% CI: 13.83; 35.76), and untreated diabetes ( $b = 7.30$ , 95% CI: 1.29; 13.31) were associated with visual acuity loss.

#### **Conclusion:**

Considering the huge differences between the health care and the population's social status of the recommendation-establishing countries and Hungary which represent non-high-income countries, the uncertain recommendation of visual acuity loss screening should not discourage general practitioners from organizing population-based screening for visual acuity loss in non-affordable populations.

#### **Keywords:**

visual acuity loss; screening; primary care; general health check; deprivation

## **7.2 Effectiveness of and Inequalities in COVID-19 Epidemic Control Strategies in Hungary: A Nationwide Cross-Sectional Study**

### **Introduction:**

Before the mass vaccination, epidemiological control measures were the only means of containing the COVID-19 epidemic. Their effectiveness determined the consequences of the COVID-19 epidemic. Our study evaluated the impact of sociodemographic, lifestyle, and clinical factors on patient-reported epidemiological control measures.

### **Methods:**

A nationwide representative sample of 1008 randomly selected adults were interviewed in person between 15 March and 30 May 2021. The prevalence of test-confirmed SARS-CoV-2 infection was 12.1% of testing was 33.7%, and of contact tracing among test-confirmed infected subjects was 67.9%. The vaccination coverage was 52.4%.

### **Results:**

According to the multivariable logistic regression models, the occurrence of infection was not influenced by sociodemographic and lifestyle factors or by the presence of chronic disease. Testing was more frequent among middle-aged adults (aOR = 1.53, 95% CI 1.10–2.13) and employed adults (aOR = 2.06, 95% CI 1.42–3.00), and was more frequent among adults with a higher education (aOR<sub>secondary</sub> = 1.93, 95% CI 1.20–3.13; aOR<sub>tertiary</sub> = 3.19, 95% CI 1.81–5.63). Contact tracing was more frequently implemented among middle-aged (aOR<sub>41-70y</sub> = 3.33, 95% CI 1.17–9.45) and employed (aOR = 4.58, 95% CI 1.38–15.22), and those with chronic diseases (aOR = 5.92, 95% CI 1.56–22.47). Positive correlation was observed between age groups and vaccination frequency (aOR<sub>41-70y</sub> = 2.94, 95% CI 2.09–4.15; aOR<sub>71+y</sub> = 14.52, 95% CI 7.33–28.77). Higher than primary education (aOR<sub>secondary</sub> = 1.69, 95% CI 1.08–2.63; aOR<sub>tertiary</sub> = 4.36, 95% CI 2.46–7.73) and the presence of a chronic disease (aOR = 2.58, 95% CI 1.75–3.80) positively impacted vaccination. Regular smoking was inversely correlated with vaccination (aOR = 0.60; 95% CI 0.44–0.83).

### **Conclusions:**

The survey indicated that testing, contact tracing, and vaccination were seriously influenced by socioeconomic position, less so by chronic disease prevalence and very minimally by lifestyle. The etiological role of socioeconomic inequalities in epidemic measure

implementation likely generated socioeconomic inequality in COVID-19-related complication and death rates.

**Keywords:** COVID-19 epidemic; epidemiological measures; effectiveness; social status; inequalities

## **8. Funding**

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## **10. Key words**

Covid-19 epidemic, Epidemiological measures, Effectiveness, Social Status, Inequalities, Visual Acuity loss, Screening, Primary care, General Health check, Deprivation, United states Preventive Service task force, Age macular degeneration, Roma ethnicity, International Social survey program, Public health Focused model, Visual impairment

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## 12. Appendix



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Subject:

PhD Publication List

Candidate: Rahul Naresh Wasnik

Doctoral School: Doctoral School of Health Sciences

### List of publications related to the dissertation

1. **Wasnik, R. N.**, Vincze, F., Foldvari, A., Palinkas, A., Sandor, J.: Effectiveness of and Inequalities in COVID-19 Epidemic Control Strategies in Hungary: A Nationwide Cross-Sectional Study. *Healthcare*. 11 (9), 1-12, 2023.  
DOI: <http://dx.doi.org/10.3390/healthcare11091220>  
IF: 2.8 (2022)
2. **Wasnik, R. N.**, Györi-Dani, V., Vincze, F., Papp, M. C., Palinkas, A., Sandor, J.: Screening for Patients with Visual Acuity Loss in Primary Health Care: A Cross Sectional Study in a Deprived Hungarian Population. *11* (13), 1-12, 2023.  
DOI: <http://dx.doi.org/10.3390/healthcare11131941>  
IF: 2.8 (2022)





### List of other publications

3. Bekele, B. B., Alhaffar, M. H. D. B. A., **Wasnik, R. N.**, Sandor, J.: The Effect of the COVID-19 Pandemic on the Social Inequalities of Health Care Use in Hungary: a Nationally Representative Cross-Sectional Study.  
*Int. J. Environ. Res. Public Health.* 19 (4), 1-17, 2022.  
DOI: <http://dx.doi.org/10.3390/ijerph19042258>
4. **Wasnik, R. N.**, Marupuru, S., Mohammed, Z. A., Rodrigues, G. S., Miraj, S.S.: Evaluation of antimicrobial therapy and patient adherence in diabetic foot infections.  
*Clin. Epidemiol. Glob. Health.* 7 (3), 283-287, 2019.  
DOI: <http://dx.doi.org/https://doi.org/10.1016/j.cegh.2018.10.005>

**Total IF of journals (all publications): 5,6**

**Total IF of journals (publications related to the dissertation): 5,6**

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