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Peer assessment as a method for measuring harmful internet use

W.W. Koczkodaj[a,*], A. Kowalczyk[b], M. Mazurek[c], W. Pedrycz[d], G. Redlarski[e], E. Rogalska[f], D. Strzalka[g], A. Szymanska[h], A. Wilinski[i], O.S. Xue[a]

[a] Computer Science, Laurentian University, Sudbury, ON P3E 2C6 Canada
[b] Ophthalmology Eye and Ear Hospital, Melbourne University, Australia
[c] Department of Complex Systems, Rzeszow University of Technology, Rzeszow, 35–959 Poland
[d] Department of Electrical and Computer Engineering, University of Alberta, Edmonton, AB T6G 2R3 Canada
[e] BioTechMed Center, Faculty of Electrical & Control Engineering, Gdańsk University of Technology, Gdańsk, Poland
[f] Institute of Pedagogy, University of Szczecin, Szczecin, 70–453 Poland
[g] Department of Complex Systems, Rzeszów University of Technology, Rzeszów, 35–959 Poland
[h] Institute of Psychology, Cardinal Stefan Wyszynski University, Warsaw, 01–815 Poland
[i] Computer Science and New Technologies Department, WSB Merito University Gdańsk, Gdańsk, Poland

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ABSTRACT

Harmful Internet use (HIU) describes unintended use of the Internet. It could be both self-harm and harming others. Our research goal is to develop a more accurate method for measuring HIU by this novel peer assessment. As such, it may become, with our call for more research, a paradigm shift supplementing every rating scale or other type of Internet use assessment. In addition to classic statistical analysis, structural equations have been employed. Results indicate that the true positive rate (TPR) is substantially higher than assessed in other studies.

- Peer assessment improvement.
- AUC for ROC was computed to establish cut-off points for the used scale.
- Results obtained by the Structural Equation model indicate that parental care has a moderate influence on subjects' attempts to fight HIU.

Specification table

Subject area:	Harmful Internet Use Measurement
More specific subject area:	Peer assessment
Name of your method:	PA4HIU measure
Reference to the original method:	W.W. Koczkodaj, et al., Combating harmful internet use with peer assessment and Differential Evolution, 2022 International Conference on Electrical, Computer and Energy Technologies (ICECET), Prague, Czech Repulic (2022). doi:10.1109/icecet55527.2022.9873437.
Resource availability:	Dataset will be available upon request for reviewing and posted on the Internet if accepted.

* Corresponding author.
E-mail addresses: wkoczkodaj@laurentian.ca (W.W. Koczkodaj), kowa@unimelb.edu.au (A. Kowalczyk), miroslaw.mazurek@prz.edu.pl (M. Mazurek), wpedrycz@ualberta.ca (W. Pedrycz), grzegorz.redlarski@pg.edu.pl (G. Redlarski), elzbietarogalska@o2.pl (E. Rogalska), strzalka@prz.edu.pl (D. Strzalka), elysium567@gmail.com (A. Szymanska), awilinski@wsb.gda.pl (A. Wilinski), sxue@laurentian.ca (O.S. Xue).

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Introduction

The Internet has improved the lives of the vast majority of people around the world. However, it has also been used harmfully, not only by criminals or terrorists. Even toddlers, ages 3 to 5 years old, excessively use smart phones and tablets by watching video material on social networks (on average 2h/day) as evidenced in [4]. We consider any activity involving the Internet causing self-harm or harming others as harmful Internet use (HIU). Examples of the positive use of the Internet, published by this journal, can be found in [5,6], and [7].

The Internet becomes a major problem when it is used to harm ourselves or others. The younger generation is particularly vulnerable. According to [8], problematic Internet use has been linked to behavioral addiction, major depressive disorder, attention deficit/hyperactivity disorder (ADHD), sleeping disorders, cognitive deficits, and suicides. "The Social Dilemma" (see [9]) presents social problems related to HIU. In it, several influential designers of popular social networks have been interviewed to evidence a major social problem.

In this study, we propose a more accurate method for measuring HIU than the self-assessment and parental assessment. It is based on peer assessment. The preliminary results of the enhancement HIU assessment were presented in [10]. They are highly encouraging.

Authors of [11] identify the most common physical complaints associated with Internet use and further investigate the association between the frequency of Internet use and individual physical health.

We provide reasoning and statistical analysis that the proposed method to measure the harmful Internet use is more accurate than both self-assessment and parental assessment.

Methods

In this study, we propose the novel application of a scientific method used for thousands of years in medicine. According to [12], "perhaps the first documented description of a peer-review process is in a book called Ethics of the Physician by Ishap bin Ali Al Rahwi (CE 854–931) of Al Raha, Syria. This work, and its later variants or manuals, states that it is the duty of a visiting physician to make duplicate notes of the condition of the patient on each visit". (see [13] and [14]). In modern science, Henry Oldenburg (also known as Henry Oldenbourg) is usually regarded as the first proponent of scientific peer review process. In the 17th century, he introduced the peer review process for Philosophical Transactions of the Royal Society (see [15]).

The self-assessment is inaccurate, as [16] evidenced it by using a survey of more than 250,000 individuals. Individuals are significantly (by 36.5%) more likely to under-report their mental disorders. According to our data analysis, most parents assessed inaccurately their child's use of mobile devices (average error: 35.3% which is consistent with [16]).

Rating scale

Rating scale is what many of us use without even realizing it. In its most common form, a rating scale is a questionnaire with a procedure of producing a meaningful total score. The questionnaire part of the scale may have different shapes, often implemented as online instruments for various types of examinations (for example, see [17]).

The importance of rating scales skyrocketed during the pandemic for academic exams. A popular form of the rating scale is the Likert scale (used in [18]). It is a selection of fixed (usually 5 or 7) items from "strongly disagree" to "strongly agree" (or similar linguistic expressions).

A scale of 0 to 3 is easier to comprehend and use. The meaning of 0 usually signifies absence or lack of knowledge, and 3 stands for the maximum of some quality of knowledge about the subject.

Fig. 1 shows the English interpretation of an example rating scale used in Poland to collect data about HIU by peers for analysis in our study. Most other existing rating scales can be customized for this use. There are many of them. The main goal of our method is to improve the accuracy of any used rating scale by applying it to peers.

Q1. I know subject's HIU.

Q2. Subject prefers HIU to socializing.

Q3. I am concerned about subject's HIU.

Q4. HIU impairs subject's health, hygiene, and eating pattern.

Q5. Subject avoids other activities.

Q6. Subject tried to decrease HIU but failed.

Q7. HIU negatively impacts subject's school/job performance.

Q8. My rating of subject's HIU.

Q9. My gender is: F – female, M – male, O – other.

Fig. 1. Rating scale.

Total # of participants	
267	
# of elementary school students	# of parent
185	82
Total # of evaluated peers	
1,518	
# of evaluated peers (of students)	# of evaluated children (of parents)
1,238	280
Age range of assessed participants	
10 to 22 (for all)	12 to 15 (for secendary school students)

Fig. 2. HIU data summary.

Data acquisition by two questionnaires

The data acquisition summary is presented by Fig. 2.

One questionnaire (non-returnable) required the respondents to provide a list of close friends and family members close to their age. Parents, grandparents, girlfriends, boyfriends, and/or guardians as they are other closely related (by an emotional connection with the subjects for an unbiased assessment) were excluded from this list. Subjects were instructed to list everyone whom they could evaluate (not just those whom they may suspect of HIU). Friendship or any kind of professional (e.g., study) relationship was regarded as acceptable, but more intimate relationships were not since they may impair the objectivity of the assessment. The second questionnaire was used to measure the HIU of the peers listed in the first questionnaire.

Analysis of Q1 indicates that 52% of respondents are familiar with the HIU patterns of assessed subjects. Social development ensures a safe and healthy relationship with individuals. However, the results obtained in the survey (question Q2) do not support it. Above 61% of children prefer socializing (in analysis, the answers with a weight of 1.5 – 3.0 were added).

Question Q2 indicates that 39% of children see a problem related to avoiding social contact. Children's behavior, as assessed by their parents, indicates that almost 52% of parents know their children's HIU pattern but do not regard it as a potential problem.

Question Q3 analysis indicates that above 65% of children and 38% of parents ignore HIU as a problem. For only 32% of parents, HIU is regarded negatively.

Question Q4 analysis indicates that approximately 78% of children and 54% of parents believe that HIU does not impair their children's health, hygiene and eating patterns. Only 19% of parents regard HIU as a contributing factor for the deterioration of health or hygiene in their children.

Question Q5 analysis indicates that nearly 67% of children and 46% of parents do not regard the avoidance of other activities as negative to the child's development (24% of parents and only 15% of children).

Question Q6 analysis indicates that nearly 73% of children and 59% of parents have not even attempted to mitigate the effects of HIU. 56% of children and 47% of parents regard that HIU has no application to the well-being of their children. Only 13.5% of parents stated that the school performance of their children had deteriorated, while 22% of children expressed concerns about their peers.

The scale threshold as ROC cut-off scale point

For rating scale (see Fig. 1) i-subject (student), the sum of $Q1$ to $Q7$

$$S_i = Q1_i + \ldots + Q7_i$$

is a linear classifier. Attribute $Q8$ is mapped to 0–1 (0 means no HIU problem present, and 1 means HIU is present). Usually, the classification rule (the scale cut-off point in our case) for 1 is assumed arbitrarily as the "golden standard" while we compute it. For the aforementioned rating scale, the cut-off scale point, we consider:

- Euclidean distance (ED) between the point (0,1) and the nearest point on the ROC curve,
- Youden index (YI).

The above indexes are defined as follows:

- Euclidean distance index:

$$ED = min[d_{eukl}[(rocX, rocY); (0,1)]] =$$

$$= min[\sqrt{(1 - specificity)^2 + (sensitivity - 1)^2}]$$

- Youden distance index:

$$YI = max(sensivity + specificity - 1)$$

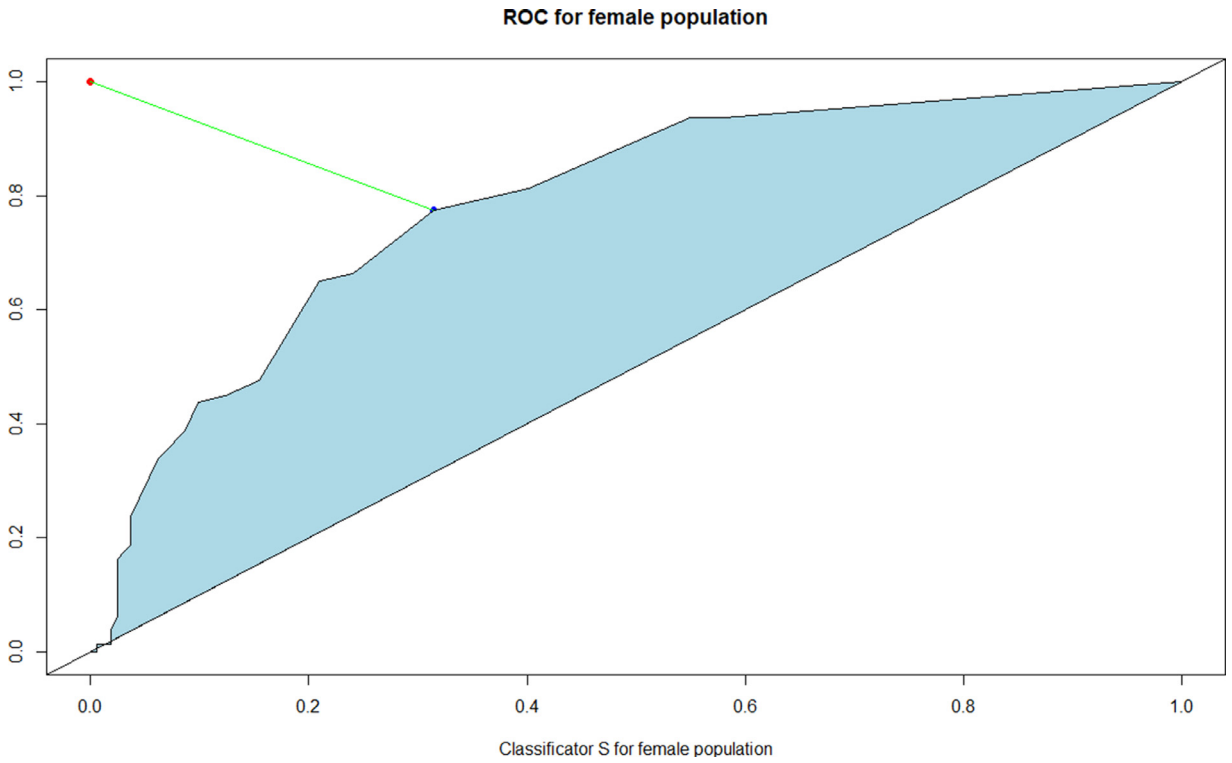

Fig. 3. Cut-off scale point for the female population.

Table 1
Distance index values.

Index ↓ /gender →	F	M
Euclidean distance	0.387	0.313
Youden	0.460	0.562

If a rating scale perfectly differentiates persons with a disorder from those without it on the basis of a single cut-off point, the ROC curve would be reflected by a vertical segment from (0,0) to (0,1). Evidently, for a less-than-perfect rating scale, the ROC curve cannot reach the point (0,1). The choice of the "optimal cut-off point" t is recommended in [19] as the closest point to (x, y) $(0, 1)$. Usually, the Euclidean distance is assumed for minimizing the miss-classification. This criterion differentiates between positive and negative cases. Figs. 3 and 4 demonstrate these points for male and female populations.

The ROC ED cut-off value for the female populations is 0.3131 on a scale of 0 to 1 and the ROC ED cut-off value for the male populations 0.1667.

Table 1 shows two popular distance indexes. The Euclidean distance (attributed to the ancient Greek mathematician Euclid in Alexandria, Ptolemaic Egypt c. 300 BCE.) is well presented in [1]. Youden index was introduced in [2] and rediscovered by Youden (see [3]).

Evidently, the two populations differ slightly. It is so since the characteristics of HIU for female and male populations differ. For example, female uses more social media along the line of Facebook and the male population plays more games. The decision of which index to select for the scale is arbitrary. We decide to use the Euclidean distance index. We need to translate it into the classifier, which is from 0 to 21. For the female population, we get 8.127 and 6.573 for the male population. The rounded values are 8.1 for females and 6.6 for males.

The scaled sensitivity is the true positive rate (TPR). It is also known as recall. We compute it as the proportion of subjects (or examples) that are positive (that is, true positive, TP) of all the subjects (examples) that actually are positive. Let us denote the "Condition Positive" as CP and "False Negative" as FN, giving CP = TP + FN. Hence, the true positive rate is

$$TPR = \frac{TP}{CP}$$

and

$$TPR = \frac{TP}{TP + FN}$$

where TP is the true positive count and P is the positive count.

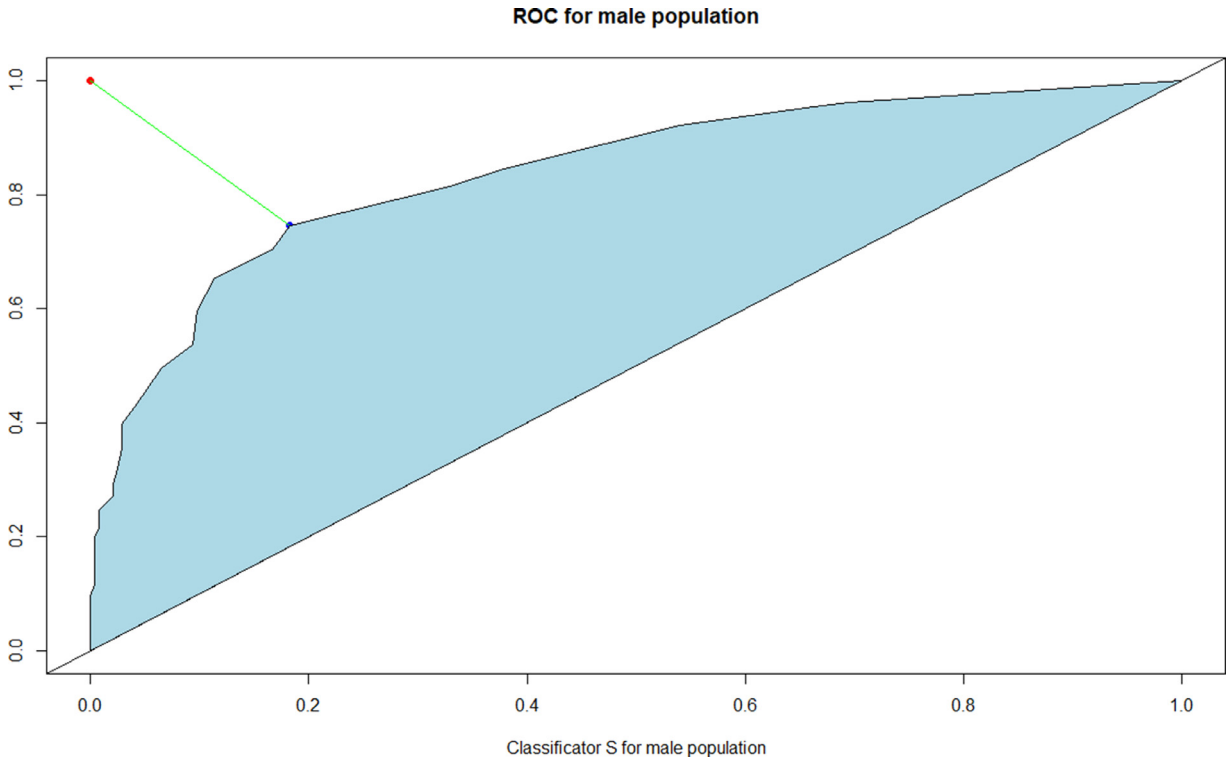

Fig. 4. Cut-off scale point for the male population.

Table 2
Population sensitivity and specificity.

Test factors ↓ /gender →	F	M
sensitivity	0.7750	0.7458
specificity	0.6851	0.8170

The scale specificity or the true negative rate (TNR) is computed as

$$TNR = \frac{TN}{CN}$$

hence

$$TNR = \frac{TN}{TN + FP}$$

In our case, the sensitivity (see Table 2) of the female population is by approx 3% higher than the male population, and both are high: 77.50% and 74.58 despite differences in using the Internet for leisure.

The sensitivity is higher for the male population when compared to the female population. Two methods for finding the cut-off points for male and female populations have been used:

1. classic Youden index (YI),
2. Euclidean distance index (EDI).

In our case, classifier S is the total score, but it can be a weighted sum with weights computed by differential evolution. The cut-off points on both Figs. 5 and 6 for female and male populations are different.

Structural equations model

One of the goals of our method was to find the relationship between an attempt to fight HIU use Q6 (often, despite the failure to succeed in it) and other factors.

Path analysis results

Our structural path analysis was used with Asymptotically Distribution Free (ADF) estimator (see [20]). It is illustrated by Fig. 7

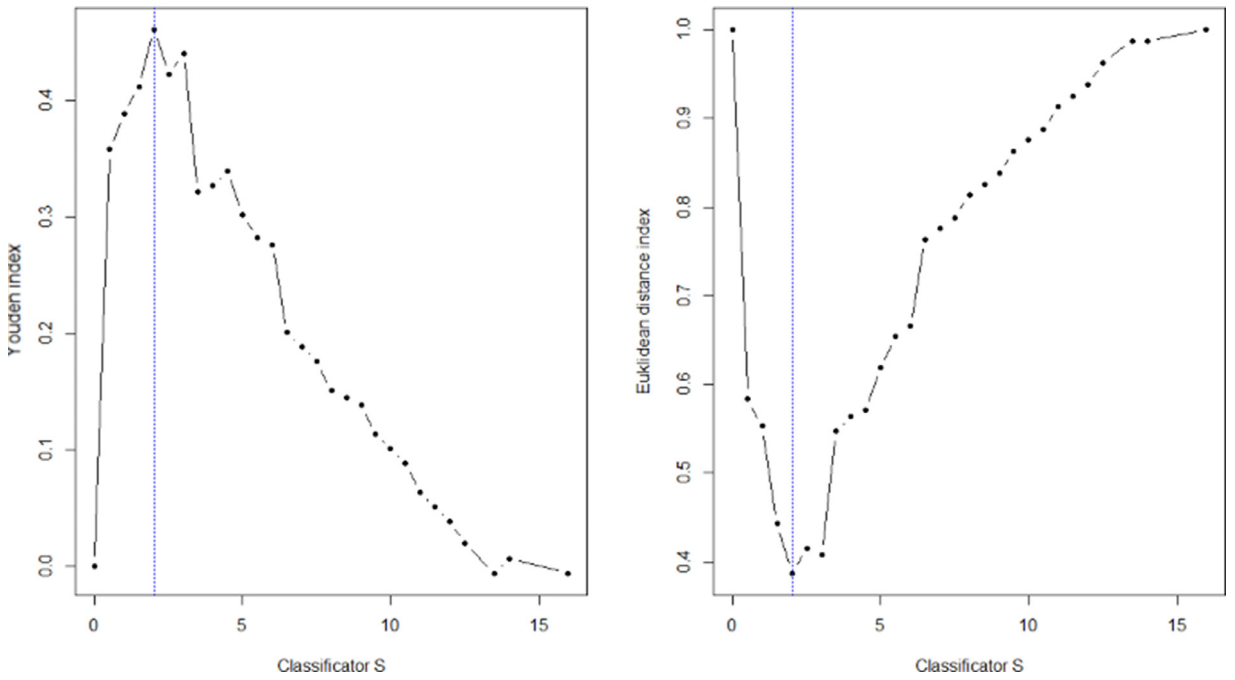

Fig. 5. Cut-off point methods for the female population.

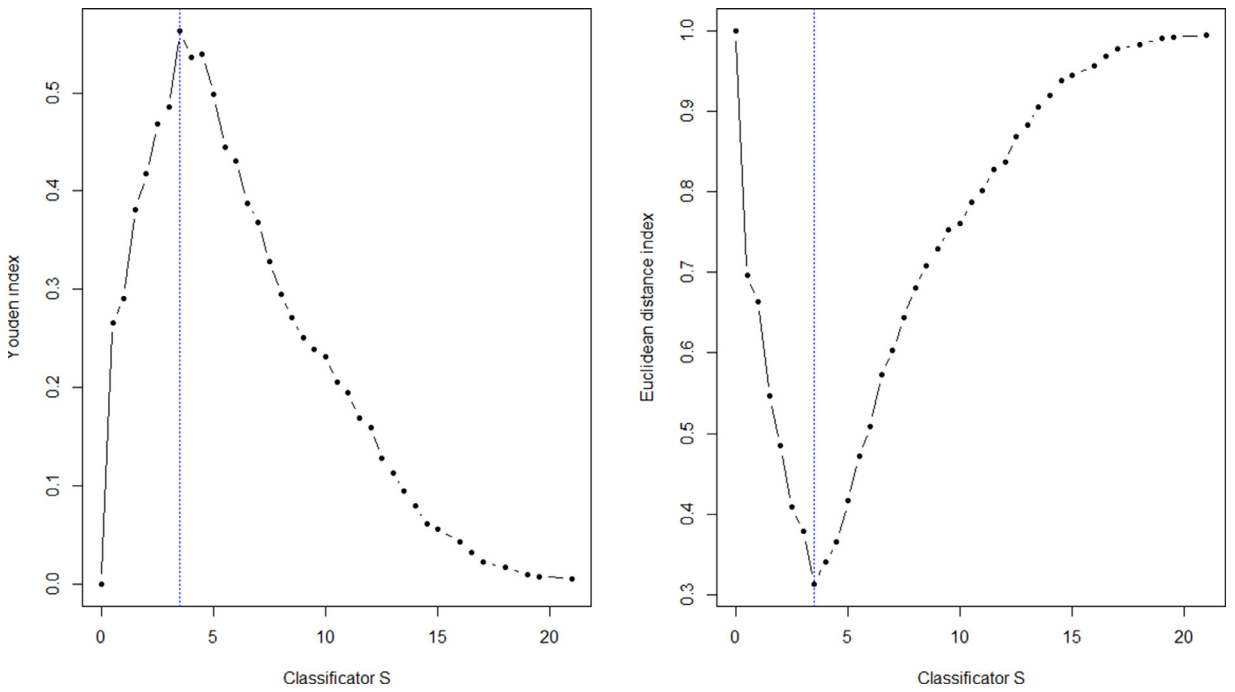

Fig. 6. Cut-off point methods for the male population.

The regression between Q8 and Q2 *is* 0.63, $p < 0.05$. The regression between Q2 and Q7 is 0.67, $p < 0.05$. This relationship implies that higher HIU and lower socializing cause lower study achievements. The regression between Q2 and Q4 is 0.80. It means that the subject prefers HIU over socializing with peers, and both of them negatively influence the health of the subject. Similarly, the regression between Q4 and Q5 is 0.75; hence, health and hygiene problems impact social interaction. The regression between Q4 and Q3 is 0.74; therefore, parents are concerned with the child's health and hygiene. The regression between Q3 and Q6 is 0.40

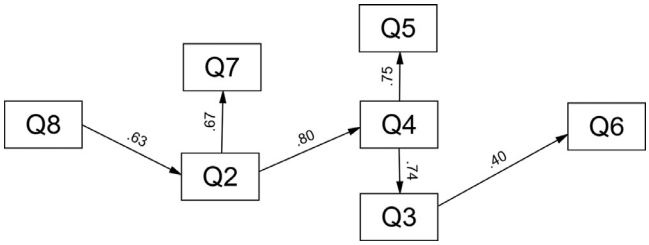

Fig. 7. Path analysis diagram.

hence moderate. It implies that parental care has a moderate influence on the subject's attempt to do something about experiencing HIU.

Conclusion

By using the proposed measurement enhancement, our study has indicated that the HIU penetration is at a much higher level among children in Poland than we have previously realized.

Our findings are consistent with common sense and observations that use measurements based on assessments by peers. We gain in accuracy when compared to self-assessments or parental assessments. Further improvement of accuracy is expected to be gained by adding approaches in [21] in the follow-up publication. Some future studies may involve other methods to subjective assessments as they may grasp different notions of the respondents' perception (e.g., [23] and [24]).

The presented models show a strong correlation between HIU and the avoidance of other activities, such as sports and live socializing. Poorer levels of hygiene, health, and nutrition pattern can also be, in part, attributed to HIU based on the results of our study.

Research in drug abuse and addiction also teaches us that parents are often the last to know about their children's addiction problems. This discouraging situation is exacerbated by the unreliability of the current measurements of Harmful Internet use. The proposed method is a more objective way of measurement, which seems to be worth additional research effort to further validate it. Poland has been classified as a high-income economy by the World Bank, ranking 22nd by GDP (nominal) and 19th worldwide by GDP (PPP). Poland is a conservative society, and it is reasonable to assume that our results (hence their importance) are representative of all developed countries. The anticipated economic costs are of considerable importance. When the amount of time spent on HIU grows, education and willingness to work productively deteriorate.

Software developers have unwillingly enabled HIU, and they should develop better ways of preventing it. Much has been done, but more is needed. We hope that our method to measuring the harm may help to monitor it better than the traditional methods of self-assessments and parental assessments since both of them are inaccurate.

This study is an example of an interdisciplinary research effort and more needs to be done. Group assessments, planned for a followup study, can be improved by: [25,26], and [27]. We also hope that the use of heuristics (see [22]) will improve the accuracy of the HIU measurement (planned for the follow-up study).

Authors' individual contributions

Authors' individual contributions cannot be easily measured, but could be viewed as followed. Conceptualization: WWK; data acquisition: MM, DS; formal analysis: WWK, MM, AS; funding acquisition: DS; investigation: all; methodology: WWK; project coordination: WWK; validation: all; visualization: WWK, MM, DS, AS, SX; roles/writing - original draft: WWK, MM; writing, reviews, validation and editing: all.

Declaration of Competing Interest

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

Data availability

Data will be made available on request.

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