Mobile Insight in Risk, Resilience and Online Referral (MIRROR): Psychometric Evaluation of an Online Self-Help Test

Merel Marjolein van Herpen, Manon Boeschoten, Hans te Brake, Niels van der Aa, Miranda Olff

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Abstract

Background: Most people who experience a potentially traumatic event (PTE) recover on their own. A small group of individuals develops psychological complaints but is often not detected in time or guidance to care is suboptimal. To identify these individuals and encourage them to seek help, a web-based self-help test called MIRROR– Mobile Insight in Risk, Resilience and Online Referral – was developed. MIRROR takes an innovative approach since it integrates both negative and positive outcomes of PTEs and time since the event, and provides direct feedback to the user.

Objective: To assess MIRROR's usage, examine its psychometric properties (factor structure, internal consistency, convergent and divergent validity) and evaluate how well it classifies respondents into different outcome categories compared to reference measures.

Methods: MIRROR was embedded in the website of Victim Support Netherlands so visitors could use it. We compared MIRROR's outcomes to reference measures of PTSD symptoms (PTSD Checklist for DSM-5), depression, anxiety, stress (Depression Anxiety Stress Scale - 21), psychological resilience (Resilience Evaluation Scale) and positive mental health (Mental Health Continuum Short Form).

Results: showed good internal consistency (inter-item correlations range: .24 to .55), convergent and divergent validity (Pearson correlations range: -.259 to .665). Exploratory and confirmatory factor analyses yielded a two-factor model with good model fit (CFA model fit indices: $\chi^2 = 107.780$, P<.001, df = 19, CFI = .965, TLI = .948, RMSEA = .065), conceptual meaning and parsimony. MIRROR correctly classified respondents into different outcome categories, compared to the reference measures.

Conclusions: MIRROR is a valid and reliable self-help test to identify negative (PTSD complaints) and positive outcomes (psychosocial functioning and resilience) of PTEs. MIRROR is an easily accessible online tool that can help victims of PTEs to timely identify psychological complaints and to find appropriate support, a tool that might be highly needed in times of the Coronavirus pandemic.

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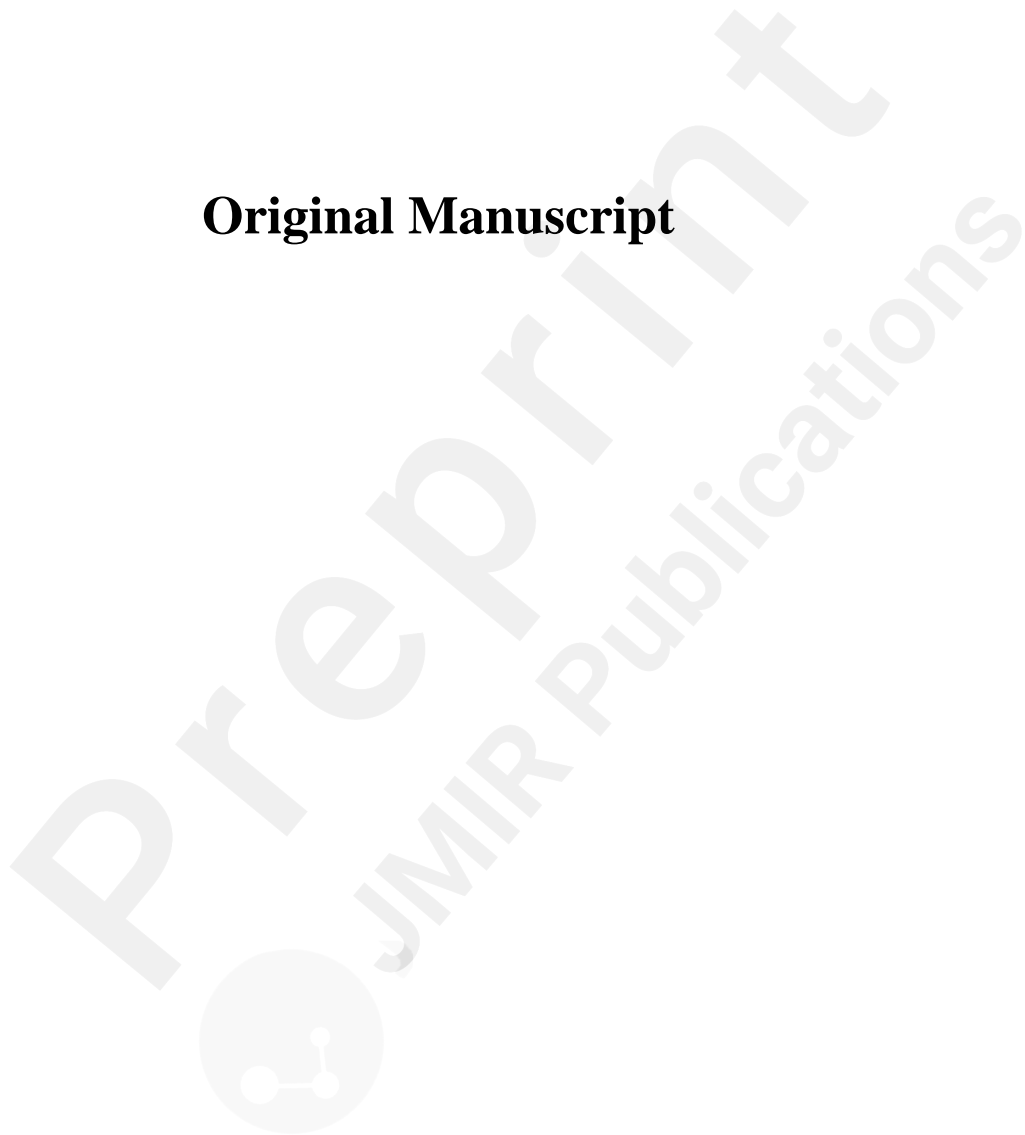
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Results: In six months, 1112 respondents completed MIRROR, of whom 663 also completed the reference measures. Results showed good internal consistency (inter-item correlations range: .24 to .55, corrected item-total correlations range: .30 to .54 and Cronbach's alpha coefficient range: .62 to .68.), convergent and divergent validity (Pearson correlations range: -.259 to .665). Exploratory and confirmatory factor analyses yielded a two-factor model with good model fit (CFA model fit indices: χ^2 = 107.780, P<.001, df = 19, CFI = .965, TLI = .948, RMSEA = .065), conceptual meaning and parsimony. MIRROR correctly classified respondents into different outcome categories, compared to the reference measures.

Conclusions: MIRROR is a valid and reliable self-help test to identify negative (PTSD complaints) and positive outcomes (psychosocial functioning and resilience) of PTEs. MIRROR is an easily accessible online tool that can help people who have experienced a PTE to timely identify psychological complaints and to find appropriate support, a tool that might be highly needed in times of the Coronavirus pandemic.

Key words: Potentially traumatic events; mobile mental health; self-help; online; resilience;

posttraumatic stress disorder

Introduction

Most people will experience at least one potentially traumatic event (PTE) in their lives [1-5]. The impact of PTEs is not the same for every individual. Research shows that most individuals are able to maintain a healthy level of functioning or resilience aftxer experiencing a PTE and psychological complaints usually diminish over time without professional support [1,6-10]. However, a small but significant group of individuals develops psychological complaints - such as post-traumatic stress disorder (PTSD) - that require care [2].

Experiencing psychological complaints a few days to weeks after a PTE is often considered normal [11-13]. The National Institute for Health and Care Excellence (NICE) advises to consider active monitoring - also known as watchful waiting – following a PTE, i.e., regular monitoring of people with some PTSD symptoms within one month of the event [14]. The TENTS guideline for post-disaster psychosocial care advises against formal screening of everyone affected by a PTE, but stresses the importance of identifying individuals in need of support. Once a PTSD has been diagnosed, early treatment is advised [14-18]. Taking these advices together, it could be concluded that support for people who have experienced a PTE is necessary, preferably early and easily accessible.

Unfortunately, the small but significant group that develops persisting psychological complaints is often not detected in time or guidance to care is suboptimal [19,20]. Guidance to care can be hindered due to people not recognizing their symptoms or having self-stigma, which prevents them from seeking help [21-24]. In addition, health care facilities may lack the resources to be able to reach people who have experienced a PTE and identify the ones who need support [23,25]. Also, general practitioners may not recognize PTSD symptoms [26] or other psychological complaints [27].

In order to prevent the development and persistence of trauma-related complaints, timely and accurate identification is needed [23,28]. Short and easy to use screening instruments could enable individuals at risk of developing psychological complaints to self-identify and monitor possible symptoms after PTEs. Moreover, providing online or mobile self-help tests can aid in timely identification of symptoms in people who have experienced a PTE, providing more information regarding normal psychological responses and in encouraging help seeking [29,30].

Multiple studies show that when one chooses to assist people who have experienced a PTE, it is important to support self-reliance and resilience [1,11,14]. Normalizing and validating emotional responses can promote the capacity to deal with these emotions [11]. Also, the extent to which individuals indicate themselves as being resilient is considered to positively influence post-trauma

outcomes [31,32]. Several self-report screening instruments are available to predict PTSD, such as the Trauma Screening Questionnaire, Impact of Event Scale-Revised or PTSD checklist for DSM-5 [33,34]. However, most instruments only screen for complaints and do not inquire about protective factors - such as psychological resilience and psychosocial functioning [33,34]. In addition, most screening instruments do not consider the time period that has passed since the event. Such information is necessary to determine whether or not reported complaints can be appraised as 'normal' given the stressful event just happened or whether referral to care is needed [14]. By not including time in classifying responses, screening can overlook or misappraise the different response trajectories that have been found after PTEs [9].

To incorporate above guideline advices and address the aforementioned concerns in the early support of people who have experienced a PTE, MIRROR - Mobile Insight in Risk, Resilience and Online Referral – was developed. MIRROR is a web-based self-help test with the potential to reach large groups of people who are seeking reassurance on how they are coping. MIRROR takes an innovative approach since it integrates both negative and positive outcomes of PTEs and time since the event. This was realized by creating a new questionnaire based on existing measures on resilience, functioning and PTSD, and by developing a new algorithm which takes into account multiple factors. In compliance with NICE, TENTS and DSM-5 guidelines [14,15,35], MIRROR's algorithm includes as main weight factors: the severity of complaints, time passed since the event, and level of psychosocial functioning. MIRROR provides users with personal advice based on respondents' answers with relevant follow-up support options such as a reminder for self-monitoring and contact information for consultation. Giving personal feedback to users is recommended to augment the use of mobile self-tests after PTEs [36]. Also, arranging active monitoring with follow-up within one month is advised [14]. Of relevance, no difference has been found between responses on a PTSD self-report administered via a mobile device versus paper administration [37]. MIRROR aims to contribute to the early identification of those who are likely to develop psychological complaints and encourage them to seek help. At the same time, MIRROR aims to support self-reliance by facilitating self-monitoring and self-recovery through follow-up support options.

While it is recognized that mobile applications have the potential to improve timely identification of complaints and delivery of mental health support after PTEs, there is very little research on their validity, reliability, and effectiveness [29,30,38,39]. Therefore, the aims of this study were to: 1) assess MIRROR's usage, 2) examine MIRROR's psychometric properties (factor structure, internal consistency, convergent and divergent validity) and 3) evaluate how well MIRROR classifies respondents into different outcome categories compared to reference measures.

Methods

MIRROR

A multidisciplinary team of professionals in the field of psychotrauma (clinicians, researchers, and policy officers) and victim and crisis support developed MIRROR. The items and algorithm were based on existing protocols - DSM-5 and ICD-10 [35,40] - best practices and recommendations of the Dutch National Multidisciplinary Guideline on Psychosocial Support in Disasters and Crises [41] and international guidelines for PTSD and post-disaster psychosocial care [14,15].

MIRROR consists of two parts. Part one includes items regarding event-related characteristics: type of event - measured with all events of the Dutch version of the Life Events Checklist for the DSM-5 [42], time passed since the event (measured in weeks), and relation to the event (happened to me, learned about it, witnessed it, part of my job). Part two consists of eight items divided in three sections. The first concerns 'PTSD core symptoms' (four items in total; one about intrusion, two about avoidance and one about arousal). The items are developed based on the clusters in the DSM-IV, DSM-5, ICD-10 and ICD-11. Higher scores reflect more PTSD symptoms. The second concerns the item *'how would you rate your present functioning (at work/home)?'*, based on the widely used Global Assessment of Functioning (GAF) score for which higher scores reflect a higher level of functioning. The third concerns 'resilience' (three items in total; about social support, self-reliance and problem solving), based on the resilience concept as introduced by Van der Meer et al. 2018 [43]. Higher scores reflect more resilience. PTSD and resilience items are answered on a 5-point response scale, ranging from 1 (never) to 5 (all the time). Functioning is rated on a scale from 1 to 10.

MIRROR's algorithm aims to identify PTSD symptoms, psychosocial functioning and resilience; to normalize complaints – i.e. reassuring users that it is normal to experience distress shortly after a PTE; and to stimulate seeking support in users with persisting complaints. See multimedia appendix 1 for an overview of the possible outcomes of the algorithm. In the algorithm, MIRROR's PTSD scale and functioning item are classified in three levels: low, moderate and high. Resilience is categorized as either low or high. The categorizations are based on the aforementioned existing protocols and best practices. MIRROR's algorithm differentiates three phases of time passed since the event: 1) less than one week ago, 2) between one and four weeks and 3) more than four weeks or reoccurring. These were based on the assumption that complaints after PTEs may occur, but generally will diminish over time; as most people recover on their own [6]. Therefore, the occurrence of PTSD core complaints with moderate to low functioning shortly after an adverse event

can be seen as normal [11-13], but if complaints and moderate to low functioning are present after one month guidance to care is needed [14-18]

MIRROR summarizes the outcome of its algorithm to respondents as either green, orange or red. Together with this color outcome respondents receive personal advice. The color outcome is based on the level of complaints, functioning and time passed since the event. MIRROR's resilience scale is not included in the color outcome because based on current research it is unclear precisely how resilience interacts with the development of PTSD complaints and functioning after PTEs. Nontheless, resilience is integrated in the personal advice to stimulate the use of social support. If respondents score low on resilience they are encouraged to seek support from close ones and individuals who have experienced similar events.

A green outcome indicates little complaints and/or sufficient functioning. Therefore, the accompanying advice states no further action is needed. An orange outcome indicates complaints and moderate functioning in combination with a PTE that happened only recently (i.e. less than one month). The accompanying advice is directed at normalizing complaints – combined with promoting watchful waiting and encouraging to set a reminder to use MIRROR again in two weeks to assess if complaints have diminished. The red outcome indicates significant complaints (i.e. low functioning or complaints with moderate to low functioning for a longer period or due to a reoccurring event) which persisted for more than a month. Therefore, the advice aims to encourage the user to seek consultation with a general practitioner or to contact Victim Support Netherlands. MIRROR provides follow-up support options with its advice, such as the opportunity to get in touch with people who have had similar experiences, reading information about dealing with stress reactions or setting a reminder to use MIRROR again in two weeks.

Participants and procedure

MIRROR was available in the Dutch language and open for each visitor on the website of Victim Support Netherlands (Slachtofferhulp Nederland). The specifically targeted sample consisted of website visitors who were automatically led to MIRROR when searching for information regarding stress reactions following a PTE. MIRROR is a responsive website, respondents did not have to download it. MIRROR can be used on mobile and non-mobile devices. To evaluate the psychometric properties of MIRROR, we added a research survey with reference measures (see details in 'Measures') after the MIRROR questions for a period of six months. We tested the usability and technical functionality of MIRROR and the research survey before making it available. Each item was presented on a new webpage.

Before starting MIRROR, respondents were invited to participate in the research survey.Participants were informed regarding the purpose of the study, duration time of the survey and data storage. Participation was voluntary and completely anonymous. Respondents received no incentive for completing MIRROR or the research survey.They were asked for informed consent to use their data for research purposes, in accordance with the European General Data Protection Regulation. The Medical Ethical Committee of the Academic Medical Center in Amsterdam exempted this study from formal review (W18_364 # 18.435).

Data collection took place between February and August 2019. Only original answers were saved in the database. That is, if respondents went back to change their answers once they already received their advice, changes were not saved. We followed data cleaning recommendations by Birnbaum [44] and Wood et al. [45]. Data were discarded when respondents did not complete all survey items. In case of identical answers on all items of the different reference measures, other systematic answering patterns, or obvious unusual missing answers on certain measures, we reviewed individual results thoroughly and discarded the data in case of doubt.

Measures

PTSD symptoms

To measure PTSD symptoms, we used the Dutch version of the PTSD Checklist for DSM-5; PCL-5 [46,47]. The PCL-5 consists of 20 items and measures symptoms of intrusion (cluster B, five items), avoidance (cluster C, two items), negative alterations in cognitions and mood (cluster D, seven items) and alterations in arousal and reactivity (cluster E, six items) in the past month. All items are answered on a 5-point scale, ranging from 0 (not at all) to 4 (extremely). The PCL-5 showed good psychometric properties in different languages [48-50]. The total score was calculated by adding all item scores. Scale scores per cluster were calculated by adding the scores of the corresponding items. Higher scores reflect more severe symptoms. Cronbach's alphas in our sample ranged between .77 and .86 for the B, C, D and E clusters. The DSM-5 rule to determine a provisional PTSD diagnosis was followed. This entails treating each item with a minimum score of 2 as a symptom endorsed and requiring at least one B symptom, one C symptom, two D symptoms, and two E symptoms [46].

Depression, anxiety, and stress

To assess other common psychological complaints after PTEs, we used the Dutch short version of the Depression Anxiety Stress scale (DASS-21) measuring depression (seven items), anxiety (seven

items) and stress (seven items) [51,52]. The DASS-21 is a valid and reliable measure [53,54]. Item scores were summed to calculate scale scores and the total score. Higher scores reflect more severe symptoms. In our sample , Cronbach's alphas were .92, .86 and .86 for depression, anxiety and stress scales respectively. A 4-point response scale measures the extent to which each state has been experienced over the past week ranging from 0 (not at all) to 4 (most certainly). To determine cut-off values, DASS-21 scale scores were multiplied by two, in accordance with the scale's manual [52]. The manual provides cut-off scores for a Dutch clinical sample. These discriminate the following categories: normal (depression < 9, anxiety <7, stress <14), mild (depression 10-13, anxiety 8-9, stress 15-18), moderate (depression 14-20, anxiety 10-14, stress 19-25), severe (depression 21-27, anxiety 15-19, stress 26-33) and extremely severe (depression >28, anxiety >20, stress >34).

Psychological resilience

We used the Resilience Evaluation Scale (RES) to assess psychological resilience [43]. The 9 items are rated on a 5-point scale ranging from 0 (strongly disagree) to 4 (strongly agree). We calculated the total score by adding all items. Higher scores reflect more psychological resilience. The RES is a valid and reliable measure [43]. In this sample, Cronbach's alpha of the total scale was .88.

Positive mental health

We assessed positive mental health with the Dutch version of the Mental Health Continuum Short Form (MHC-SF) [55,56]. The MHC-SF measures emotional wellbeing (3 items), social wellbeing (5 items) and psychological wellbeing (6 items). Items were rated on a 5-point scale ranging from 0 (never) to 5 (every day). The MHC-SF is a valid and reliable instrument [56,57]. We calculated the total score by summing all item scores. Higher scores reflect more positive mental health. In this sample, Cronbach's alpha of the total scale was .93.

Google Analytics

Google Analytics data were collected between March and August 2019 to examine MIRROR's usage. Due to technical problems, data from February 2019 was missing. The data provide information on the number of unique visitors, number of unique visits per page, type of device used, number of visitors who have started MIRROR (defined as a visitor on MIRROR's start page) and who have finished MIRROR (defined as visitors on MIRROR's outcome and advice page). Google Analytics cannot determine to what extent the follow-up options were used, but it can detect how

many respondents have visited the follow-up support option pages.

Statistical analyses

Sample and usage

Since participation in the research survey was optional, this resulted in two samples. The "MIRROR-only sample" consists of respondents who only completed MIRROR. The "validation sample" includes respondents who completed MIRROR and the accompanied survey with reference measures before receiving their advice. The total sample combines these two samples, consisting of all respondents. To examine if the validation sample was representative of 'the MIRROR user', we used independent-samples t-tests in SPSS version 23 [58] to compare the MIRROR-only sample with the validation sample based on their MIRROR scores and event-related characteristics.

We used the total sample to evaluate MIRROR's usage and to examine MIRROR's factor structure and internal consistency, because for these analyses only data from MIRROR were needed. We used the validation sample to examine MIRROR's convergent and divergent validity and to evaluate how well MIRROR classifies respondents into different outcome categories, because for these analyses data from MIRROR as well as reference measures from the accompanied survey were needed.

MIRROR's factor structure

We used MPlus version 8 [59] to conduct exploratory factor analysis (EFA) using geomin rotation and confirmatory analysis (CFA). EFA assumes that any item may be associated with any factor. CFA specifies expected relationships between the items and their underlying latent factors. Because items of MIRROR's PTSD and resilience section were categorical they were treated as ordinal and therefore the means and variance adjusted weighted least square (WLSMV) estimator was used. An underlying normal distribution was assumed for each ordinal item, where the five response categories were divided by four thresholds which were estimated from the data. MIRROR's functioning item has ten response categories and was treated as continuous. Because MIRROR's factor structure was not tested before, several models with different number of latent factors were examined using EFA. To assess the model with the optimal number of latent factors needed to adequately account for the correlations among item scores, we used Kaiser criterion (i.e. eigenvalues of the latent factors > 1) and model fit statistics. The model with the best balance between model fit, parsimony and conceptual interpretability was selected as the most optimal model. Subsequently,

CFA was used to test the optimal model based on EFA. The difference in goodness-of-fit between nested models was evaluated with the 'difftest' option in MPlus for appropriate χ^2 difference testing with the WLSMV estimator [59]. The χ^2 difference test is highly sensitive to sample size such that even trivial differences between two nested models may be significant [60]. Therefore, we also assessed the difference in CFI. A difference in CFI < 0.01 indicates a better fit of the nested model compared to the more complex model [60]. For EFA and CFA, the model fit indices Comparative Fit Index (CFA), Tucker-Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA) were used to evaluate model fit. Model fit can be considered good when CFI and TLI are close to .95, and RMSEA < .06 [61]. If RMSEA < .08 model fit can be considered adequate [61].

Internal consistency

We evaluated internal consistency of MIRROR's PTSD and resilience section with inter-item correlations, corrected item-total correlations and Cronbach's alpha in SPSS version 23 [58]. Internal consistency of MIRROR's functioning section could not be evaluated since it is represented by only one item. When most inter-item correlations are in the recommended range of .15 - .50 (moderate magnitude) and Cronbach's alpha for the scale is > .80, internal consistency can be considered as good [62]. Cronbach's alpha is a function of scale length, and therefore is likely to be lower for MIRROR's scales since they consist of 3 or 4 items [62]. Corrected item-total correlations were computed to assess whether item scores regarding PTSD and resilience are associated with overall PTSD and resilience scores.

Convergent and divergent validity

To evaluate MIRROR's convergent and divergent validity, we calculated Pearson correlations between the MIRROR scales and reference measures. Convergent and divergent validity can be considered good when the correlations between a scale and equivalent measure (e.g. MIRROR's PTSD scale and the PTSD scale of the PCL-5) are significant and high while correlations between this scale and other related measures (e.g. MIRROR's PTSD scale and depression scale of the DASS-21) are lower and moderate or modest in magnitude.

MIRROR's classification quality

To evaluate how well MIRROR classifies respondents into a red, orange, or green outcome, we tested whether respondents in these three outcome categories differed on related reference measures

by using cross-tabs and ANOVA. If the assumption of equal variances was violated, we used the *Welch F* test and Games-Howell post hoc test. MIRROR's PTSD scale score was calculated by summing the four PTSD items. Higher scores reflect more severe symptoms. MIRROR's resilience scale score was calculated by a summing the three items. Higher scores reflect more resilience. Provisional PTSD diagnosis based on PCL-5 were used to classify respondents. To examine the distribution on depression, anxiety and stress symptoms, respondents were classified by comparing their scores to a Dutch clinical reference group. Respondents with normal and mild complaints compared to the reference group were classified into one group representing sub-clinical complaints. Respondents with average, severe and very severe complaints compared to the reference group were classified into another group, representing clinical complaints. Since no reference groups were available with regard to the RES and MHC-SF, the sample was divided into tertiles (i.e. three groups of equal size divided by the 33rd and 66th percentile) based on the total scores of the RES and MHC-SF. With regard to the RES, the first tertile (scores ≤ 17) was assumed to represent relatively low psychological resilience, the second tertile (scores between 18 - 24) relatively moderate psychological resilience, and the third tertile (scores between ≥ 25) relative high psychological resilience. With regard to the MHC-SF, the first (scores ≤ 23), second (scores between 24 - 47), and third tertile (scores ≥ 48) were respectively assumed to represent relatively low, moderate, and high positive mental health.

Results

Sample and usage

MIRROR was completed 1314 times in the study period of six months. 682 out of 1314 (51.9%) respondents started the research survey. We deleted 51 respondents who indicated to have used MIRROR on behalf of a family member, partner, friend or colleague who experienced a PTE. We deleted 37 repeated measurements, completed by respondents who set a reminder. We excluded 95 respondents because they did not complete all research survey items. After thorough investigation of the answering patterns, we deleted 19 respondents because of unusual answering patterns. A total of 1112 out of 1314 respondents (84.6%) respondents were retained in the total sample, of whom 663 respondents (59.6%, validation sample) also completed all questionnaires of the accompanying research survey.

Table 1 presents the MIRROR scores, outcomes and event-related characteristics for the MIRROR-only and the validation sample. We found no significant difference between the samples on MIRROR's PTSD scale: *t* (1110) = -.401, *P*= .689; resilience scale: *t* (1110) = .752, *P*= .452; or

level of functioning t (1110) = 1.547, P = .122. We found a significant association between sample and MIRROR outcome: χ^2 (2, N= 1112) = 18.99, P<.001; the validation-sample consisted of more respondents with the red MIRROR outcome than the MIRROR-only sample. The event-related characteristics for both samples were similar, see Table 1. Overall, the validation sample can be considered representative of all MIRROR users in this study period. In the validation sample, 492 out of 663 (74.2%) respondents were female. Almost half (300 out of 663; 45.3%) of respondents were between 21 and 40 years old. Table 2 presents the frequency distribution for MIRROR's response categories.

Table 1. MIRROR scores, outcomes and event-related characteristics for the validation sample and MIRROR-only sample

	Validation[a] (N=663)	MIRROR-only[a] (N=449)
MIRROR scores	*M (SD)*	*M (SD)*
MIRROR PTSD scale	14.88 (3.39)	14.80 (3.28)
MIRROR functioning	4.92 (1.96)	5.11 (1.94)
MIRROR resilience scale	10.08 (2.36)	10.91 (2.37)
MIRROR outcome[a]	%	%
Red	61.7	49.9
Orange	34.7	47.7
Green	3.6	2.4
Type of event (LEC-5)	%	%
Another very stressful event or experience	32.6	33.4
Transportation accident	17.4	23.8
Physical assault	16.5	11.1
Sudden accidental death	5.7	4.5
Serious accident at work, home, or during recreation	5.0	6.2
Sexual assault	5.0	4.0
Assault with a weapon	4.5	5.6
Other unwanted or uncomfortable sexual experience	4.5	3.1
Sudden violent death	3.6	3.6
Severe human suffering	2.1	1.1
Life-threatening illness or injury	1.5	1.1
Fire or explosion	1.4	0.9
Combat or exposure to a war-zone	0.2	0.0
Captivity	0.0	0.9
Serious injury, harm or death caused by you to someone else	0.0	0.7
Natural disaster	0.0	0.0
Relation to the event	%	%
The event happened to me	72.5	69.3
I have witnessed the event	19.5	20.9
I learnt about the event	6.3	7.8

Other[b]	1.7	2.0
Work-related	%	%
No	88.4	84.4
Yes	11.6	15.6
Time since the event	%	%
Less than one week	36.3	48.6
Over four weeks	32.3	25.2
Between one and four weeks	21.7	20.0
It happens repeatedly	9.7	6.2

[a]$P<.001$ [b]*If respondents could not select one of the event relations (happened to me, witnessed it, learnt about it, work-related) they are asked to specify their relation to the event.*

Table 2. Frequency distribution in percentages (%) of MIRROR items responses categories (N = 1112)

Scale	Item	Never		Rarely		Sometimes	Often		All the time	
PTSD	1	2.7		5.7		16.6	38.5		36.5	
	2	5.1		8.5		19.3	27.4		39.6	
	3	9.3		13.8		26.9	22.9		27.1	
	4	8.5		11.4		26.7	26.8		26.6	
Resilience	6	5.3		8.5		21.7	35.3		29.3	
	7	7.3		15.6		35.2	30.5		11.5	
	8	5.2		15.1		45.6	28.1		5.9	
		1	2	3	4	5	6	7	8	9	10
Functioning	5	4.9	6.9	10.4	15.8	19.8	20.9	12.1	6.3	1.6	1.3

A detailed overview of the scores of the validation sample on the reference measures can be found in multimedia appendix 2. Overall, these show a high level of complaints in our sample and rather low levels of psychological resilience and positive mental health (also see Table 6 and figure 1 for reference measures of each MIRROR outcome category).

Google Analytics data provided insight in MIRROR's usage. The number of visitors that started MIRROR was 2555, of whom 2247 (88%) finished it. The original database contained 1314 entries. This discrepancy can be explained by users having the opportunity to refuse to have their data saved before starting. Of all users, 1216 out of 2555 (47.6%) chose this option. Furthermore, of the follow-up support options the *"seek contact with Victim Support Netherlands"* page had most views (411 unique views), followed by *"more information"* (293 unique views), *"send your advice to yourself or someone else"* (235 unique views), *"seek contact with people who have had similar experiences"* (209 unique views) and *"set a reminder"* (161 unique views). 113 out of the 394 (28.7%) respondents who received the orange outcome and were advised to fill out MIRROR again in two weeks immediately set a reminder to complete MIRROR again in two weeks. 25 out of 113

(22.1%) did at the time of data analyses. The most often used device was the smartphone (59%) followed by desktop (33%) and tablet (8%).

MIRROR's factor structure

Table 3 presents the factor loadings for the two-factor and three-factor solution model of MIRROR as estimated by EFA. EFA yielded a three-factor solution with good model fit based on all fit indices. The Kaiser criterion was met for the first two factors, eigenvalues of the third until eight factor were <1. The three-factor solution separated MIRROR's PTSD items into two factors; one factor with the intrusion item and one factor with the avoidance and arousal/reactivity items. However, item 2 ("*have you become jumpy and/or vigilant since the event?*") cross-loaded significantly on two factors within the model, with only a small difference between the two factor loadings (λ = 0.030). This indicates that item 2 did not sufficiently distinguish between both factors. The three-factor solution clustered the functioning item with the resilience items into a third factor.

Table 3. Geomin rotated factor loadings for the two-factor and three-factor solution model of MIRROR as estimated by EFA (N = 1112)

	2-factor solution		3-factor solution		
	F1	F2	F1	F2	F3
1. Are you troubled by images of or thoughts about the event?	0.525*	-0.004	0.813*	0.015	0.018
2. Have you become jumpy and/or vigilant since the event?	0.585*	-0.009	0.308*	0.338*	-0.012
3. Do you try to avoid things that are related to the event?	0.789*	0.071	-0.000	1.078*	0.245*
4. Do you try to avoid thinking about the event?	0.648*	-0.016	0.208*	0.459*	-0.019
5. How would you rate your present functioning (at work/home)?	-0.153*	0.354*	-0.213*	0.004	0.360*
6. Do you experience support from those close to you?	0.081*	0.388*	0.160*	-0.064	0.374*
7. Are you confident in yourself?	0.006	0.827*	0.010	-0.021	0.827*
8. Are you able to deal with any problems you encounter?	-0.015	0.730*	-0.074	0.018	0.718*

*Eigenvalues: 1 = 2.777, 2 = 1.466, 3 = .927, 4 = .715, 5 = .668, 6 = .640, 7 = .437, 8 = .369. Model fit indices for the two-factor solution: χ^2 = 88.728, P<.001, df = 13, CFI = .969, TLI = .933, RMSEA = .072. Model fit indices for the three-factor solution: χ^2 = 12.565, P= .084, df = 7, CFI = .998, TLI = .991, RMSEA = .027. * P<.05.*

EFA yielded a two factor solution with adequate model fit. The RMSEA and TLI indicated adequate model fit and CFI indicated good model fit (Table 3.). The Kaiser criterion was met for the first two factors, eigenvalues of the third until eight factor were <1. The first factor of the two-factor solution consisted of the PTSD items and the second factor consisted of the functioning and resilience items. No cross-loadings were observed in this model.

Next, we conducted CFA to further compare the two- and three-factor model that resulted from EFA. Table 4 presents the model fit indices based on CFA of both aforementioned models. The model fit indices were similar for both models; the CFI and TLI indicated good model fit, the RMSEA acceptable model fit. As indicated by the significant χ^2 difference test, the two-factor model has worse model fit compared to the three-factor model (χ^2 (2, N= 1112) = 13.63, P=.001). However, the difference in CFI is < 0.01, indicating the two-factor model does not have worse model fit. We selected the two-factor model as the best-fitting model to our data, given the χ^2 difference test is sensitive to sample size, the CFI difference is <.001 and because it is more more parsimonious and better interpretable at a conceptual level compared to the three-factor model. The two-factor model represents a clear distinction between negatively formulated outcomes (PTSD complaints) and positively formulated outcomes (psychosocial functioning and resilience) of PTEs. The positively formulated outcomes combine psychosocial functioning, social support, self-reliance and problem solving. We therefore propose to rename this factor "psychosocial resources".

Table 4. Confirmatory factor analyses model fit indices (N= 1112)

Model	χ^2	P	df	CFI	TLI	RMSEA
Two-factor solution	107.780	<.001	19	.965	.948	.065
Three-factor solution	95.868	<.001	17	.969	.949	.064

Internal consistency

Inter-item correlations of MIRROR's PTSD complaints scale ranged between .28 and .48 with a mean of .34. All of the inter-item correlations of the PTSD scale were in the recommended range of moderate magnitude of .15-.50, indicating that this scale has high internal consistency in combination with a differentiated item set. Corrected item-total correlations for this scale ranged between .39 and .54 with a mean of .46, indicating that high scores on the PTSD items are associated with high scores on the overall PTSD scale of MIRROR. Cronbach's alpha coefficient for MIRROR's PTSD scale was .68.

Inter-item correlations of MIRROR's resilience scale ranged between .24 and .55, with a mean of .36. One - out of three - inter-item correlations was higher than the recommended range of moderate magnitude of .15-50 (between *'are you confident in yourself'* and *'are you able to deal*

with any problems you encounter'), indicating that this scale has high internal consistency in combination with a differentiated item set. Corrected item-total correlations ranged between .30 and .52 with a mean of .44, indicating that high scores on the resilience items are associated with high scores on the overall resilience scale of MIRROR. Cronbach's alpha coefficient for MIRROR's resilience scale was .62.

Convergent and divergent validity

Pearson correlations between MIRROR and reference measures are presented in Table 5. MIRROR's PTSD scale showed strongest correlations with PTSD as measured with the PCL-5, followed by a lower but still substantial correlation with psychological complaints as assessed with the DASS-21. The weakest correlations were observed between PTSD symptom severity as assessed with MIRROR and psychological resilience and positive mental health. MIRROR's resilience scale showed strongest correlation with psychological resilience (RES), followed by a slightly lower correlation with positive mental health, psychological complaints (DASS-21) and PTSD (PCL-5). MIRROR's functioning item showed strongest correlations with psychological complaints (DASS-21), followed by PTSD (PCL-5) and lower correlations with positive mental health (MHC-SF) and psychological resilience (RES). In conclusion, the correlational structure indicates good convergent and divergent validity of MIRROR's PTSD subscale. The correlational structure with regard to MIRROR's resilience scale and functioning item indicates adequate convergent and divergent validity.

Table 5. Correlations between MIRROR subscales and reference measures (N = 663)

MIRROR	PTSD	P	Resilience	P	Functioning	P
PCL-5	.665	<.001	-.507	<.001	-.442	<.001
DASS-21	.486	<.001	-.539	<.001	-.449	<.001
RES	-.265	<.001	.612	<.001	.279	<.001
MHC-SF	-.259	<.001	.603	<.001	.319	<.001

MIRROR's outcome classification

We expected respondents with the red MIRROR outcome to report more PTSD symptoms and depression, anxiety and stress complaints, and lower psychological resilience and positive mental health compared to respondents with the green and orange MIRROR outcome. Table 6. presents the the means and standard deviations on the reference measures for each MIRROR outcome category. Figure 1 shows the classification percentages on reference measures of each MIRROR outcome category. Both table 6 and figure 1 show that respondents with the red MIRROR outcome category report higher complaints and lower psychological resilience and positive mental health compared to

the orange and green MIRROR outcome category.

Table 6. Means and standard deviations of reference measures for each MIRROR outcome category (N = 663)

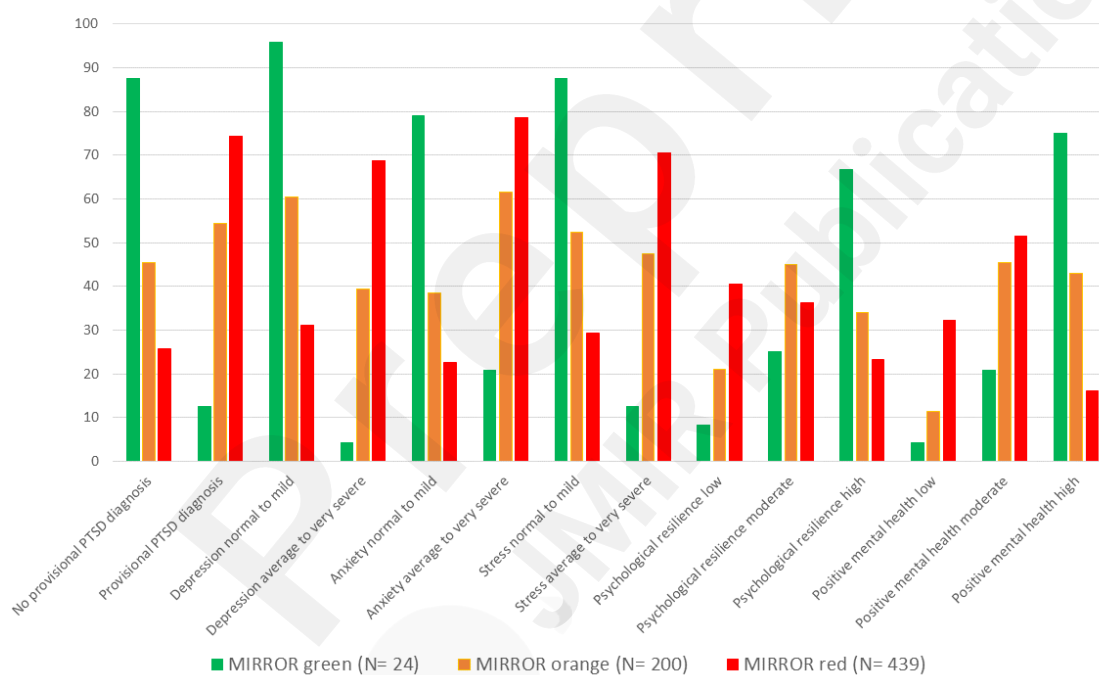| MIRROR outcome category (N)	Green (N= 24)	Orange (N=200)	Red (N=439)
	M (SD)	M (SD)	M (SD)
PTSD (PCL-5)	18.04 (12.49)	36.09 (15.77)	46.13 (14.04)
Depression (DASS-21)	4.08 (8.10)	11.73 (11.54)	19.66 (11.54)
Anxiety (DASS-21)	5.25 (6.72)	14.03 (10.27)	18.04 (10.30)
Stress (DASS-21)	10.42 (7.32)	17.60 (9.20)	22.49 (9.37)
Psychological resilience (RES)	25.58 (5.11)	22.04 (6.02)	18.82 (7.15)
Positive mental health (MHC-SF)	50.0 (12.05)	43.11 (14.89)	31.42 (14.28)

Figure 1. Classification percentages on reference measures of each MIRROR outcome category

We conducted several one-way between-groups analysis of variance (ANOVA) to investigate the difference in mean scores on the reference measures between MIRROR outcome categories. As can be seen, negative outcomes were highest for the red MIRROR outcome category and positive outcomes highest for the green outcome category. The ANOVA results are shown in table 7. We found significant differences in PTSD symptoms, depression anxiety and stress, psychological resilience and positive mental health between groups. Post hoc tests revealed that PTSD symptoms,

depression, anxiety and stress complaints were significantly different between all groups (*P*<.001). Psychological resilience was significantly higher for the green and orange MIRROR outcome category compared to the red category (*P*<.001). It was also significantly higher for the green category compared to the orange category (*P*= .010). Positive mental health was significantly higher for the green and orange category compared to the red category (*P*<.001). There was no significant difference between the green and orange category (*P*= .069).

Table 7. One-Way Between-Groups Analysis of Variance (ANOVA) with MIRROR outcome categories and reference measures

	F	*Cohen's d*	*df between groups*	*df within groups*	*P*
PTSD symptoms[a]	73.32	.168	2	62.90	<.001
Depression*	65.21	.136	2	65.81	<.001
Anxiety[a]	42.48	.072	2	67.37	<.001
Stress	34.15	.094	2	660.0	<.001
Psychological resilience[a]	30.13	.068	2	65.44	<.001
Positive mental health	57.79	.069	2	660.0	<.001

[a]The assumption of equal variances was violated. Therefore, the Welch F test and Games-Howell post hoc test were used.

Discussion

Principal Results and Comparison With Prior Work

The purpose of this study was to evaluate the usage and psychometric and classification properties of MIRROR. MIRROR is an innovative web-based self-help test to identify individuals who develop psychological complaints after a potentially traumatic event (PTE), encourage them to seek help and support self-reliance. Our results indicated that MIRROR is a valid and reliable self-help test to identify negative outcomes (PTSD core symptoms) and positive outcomes (psychosocial functioning and resilience). MIRROR is able to correctly classify respondents according to their PTSD complaints and scores on reference measures. During the study period, 2247 out of 2555 (88%) of

respondents that started MIRROR completed it.

We found that MIRROR's presupposed model of three factors (PTSD symptoms, psychosocial functioning and resilience) did not fit our data best. Instead, a two-factor solution showed good model fit, conceptual meaning and maximum parsimony. This model separates MIRROR's PTSD items from the functioning and resilience items (social support, self-reliance and problem solving). In retrospect, the grouping of the functioning and resilience items is not entirely surpising. If we assume stress to be the result of an imbalance between perceived external and internal demands and perceived personal and social resources [63], it is likely that this distinction between demands and resources is reflected in the way people cope with PTEs. We propose to call the factor "psychosocial resources". In accordance with this distinction, the two-factor model clearly separates negative (PTSD complaints) and positive (psychosocial resources) outcomes of PTE's. This is in line with the general notion that PTSD and psychosocial resources are separate constructs [64-66].

The convergent and divergent validity of MIRROR is supported by the correlations that were found between MIRROR and the reference measures. The results indicate good convergent and divergent validity for MIRROR's PTSD items. As expected, MIRROR's PTSD showed strongest correlations with PTSD (assessed with the PCL-5), followed by a lower but substantial correlation with psychological complaints (measured with the DASS-21). MIRROR's PTSD items showed low correlations with positive reference measures (assessed with the RES and MHC-SF). The results indicate adequate convergent and divergent validity for MIRROR's resilience items, but less distinct than MIRROR's PTSD. MIRROR's resilience items showed strongest correlations with psychological resilience, followed by slightly lower but substantial correlations with the other reference measures. The results in this study correspond with the finding of Van der Meer et al. [43] who found the RES total scale to be positively associated with established measures for resilience, self-esteem, self-efficacy and global functioning; and negatively associated with PTSD symptoms. Furthermore, the different patterns of correlations for MIRROR's PTSD and resilience scales agrees with the notion that PTSD and resilience are two separate constructs [64-66]. MIRROR's functioning item showed the strongest correlation with psychological complaints and PTSD and lower correlations with the positive reference measures. This indicates adequate convergent and divergent validity. The factor analyses revealed that functioning belongs to the resilience items of MIRROR. However, the correlation between MIRROR's functioning item and psychological complaints and PTSD is in line with studies that show that psychosocial functioning can be impaired by psychological complaints [65,67,68].

We found that both MIRROR's PTSD and resilience scales show good internal consistency. The Cronbach's alpha coefficients for these scales are relatively low (.68 and .62, respectively), but not unusual given the (intentionally) short scales of MIRROR and given that Cronbach's Alpha is a function of scale length [62]. Because MIRROR contains only few items, we calculated inter-item and item-total correlations. The results indicate that both scales have high internal consistency and that high scores on the items are associated with high scores on the overall scales.

MIRROR was able to correctly classify respondents into green (no further action needed), orange (encourage self-monitoring) or red (encourage seeking consultation) outcome categories and advices, compared to the other measures. Results showed that respondents with a red outcome reported to have more severe PTSD symptoms, more severe depression, anxiety and stress complaints and lower psychological resilience and positive mental health, compared to respondents with a green or orange outcome. The occurrence of PTSD and other stress-related complaints like depression following traumatic exposure is in line with former results [69]. It is important to recognize that MIRROR is specifically evaluating the risk of developing PTSD instead of other mental health outcomes of PTEs such as depression, anxiety and substance abuse. If a respondent experiences low functioning, they will receive the advice to seek consultation with their general practitioner, despite of the level of their PTSD complaints. This is based on the assumption that low functioning but no PTSD complaints may indicate that other problems could be at hand, such as depression, anxiety or substance abuse. Importantly, MIRROR appears to adequately identify users with more severe complaints and validly advices them to seek help. Our results seem to underline the relevance of including the factor 'time since the event' in MIRROR's algorithm. According to the PCL-5, 109 out of 200 (54.5%) of the respondents with the orange outcome had a provisional PTSD diagnosis. However, their complaints could still diminish, considering the event happened only recently for these respondents and research has shown that in most individuals complaints usually diminish over time [1,2,11]. Therefore, in accordance with international guidelines [14], respondents with the orange outcome are advised to monitor how their complaints develop (by setting a reminder to use MIRROR again in two weeks).

The evaluation of MIRROR's usage with Google Analytics showed that the number of users of MIRROR was substantial (N= 2555) and the completion rate was high (87.8%). These results are in line with former studies on applications assessing and monitoring mental health after PTEs indicating high usage [29,30,36] and high completion rate [49]. In general, the follow-up options were visited less frequently (161 – 411 unique visits) than the outcome and advice page (2247 unique visits). A reason for this could be that receiving MIRROR's outcome and advice is sufficient initial

support for people who have experienced a PTE, providing insight into how they are coping. 113 out of 194 (28.7%) respondents who were advised to fill out MIRROR again in two weeks immediately set a reminder, suggesting MIRROR is able to support self-monitoring. Unfortunately, this study's design and considerations of ethical nature did not enable us to assess usage in more depth.

Future Research and Limitations

Although guidelines on screening for PTSD complaints and post-disaster psychosocial care are widely available [7,15,70-72] the challenge remains how to reach and identify people at risk of developing psychological complaints after a PTE on a large scale. Future research could focus on investigating the implementation of MIRROR on a larger scale, for example after terrorist attacks or natural disasters. Literature is inconclusive about the benefits versus disadvantages of formal screening of an entire population after a disaster or crisis [14,15,70,73]. Because of limited evidence of effectivity and sensitivity of screening, organizational efforts related to screening and the often scarce resources available [25,74] it is generally not recommended to perform formal screening of complaints among all involved people following incidents. At the same time, we know that early recognition and timely referral to help are essential for preventing and treating traumatic stress symptoms. This is supported by evidence of the effectiveness of early psychological interventions for individuals pre-screened with traumatic stress symptoms shortly following trauma, and no benefits in those not pre-screened for these symptoms [16]. Mobile applications such as MIRROR can make a contribution to solving the "screening dilemma" by supporting low key, accessible and easy to use self-assessment and -monitoring. In this view, MIRROR could be implemented as a first step in the support for people who have experienced a PTE, before having to consult professional care [29,36]. MIRROR might lower the barrier to seek help given its open accessibility and anonymity. Future research could focus on acquiring longitudinal data of MIRROR to assess the development of complaints, functioning and resilience over time and establish MIRROR's ability to correctly classify users accordingly. Also, qualitative research might clarify what actions users take as a result of MIRROR's personal advice.

Our study has some limitations. In our validation sample, 492 out of 663 (74.2%) respondents were female and 300 out of 663 (45.3%) respondents were between 21 and 40 years old. This could lead to selection bias and limited generalizability of the results, which is common with "open" internet surveys [75]. However, our sample is a specifically targeted sample, because it consisted of visitors of the website of Victim Support Netherlands. Considering website visitors were automatically led to MIRROR when searching for information regarding stress reactions following a

PTE, a high prevalence of psychological complaints after traumatic exposure in our sample could be expected. Moreover, research has shown that women have a higher risk of developing PTSD compared to men [76], they are more likely to seek medical or health-related information online [77] and young people use the internet as their main source of information, also for mental health concerns [78,79]. This demonstrates that the targeted sample was reached. The main strength of this study is by comparing MIRROR to broader-used reference measures, it contributes to the highly needed evidence-base of mobile applications with the potential to improve timely identification of psychological complaints [29,30,80].

Conclusions

Concluding, this study shows that MIRROR is a psychometrically sound, anonymous and easy-accessible self-help test for people who have experienced a PTE. It is able to identify both negative (PTSD symptoms) and positive (psychosocial resources) outcomes of PTEs and to classify respondents in accordance with reference measures. This study will hopefully contribute to enhancing adequate and timely identification of people who suffer from psychological complaints after PTEs.

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Data Sharing Statement

The datasets generated and analysed during this study are available from the corresponding author on reasonable request.

Conflict of interest

Funding

Multimedia   appendix

Multimedia appendix 1 [Overview of MIRROR's outcomes]
Multimedia appendix 2 [Sample characteristics on reference measures and demography (N = 663)]

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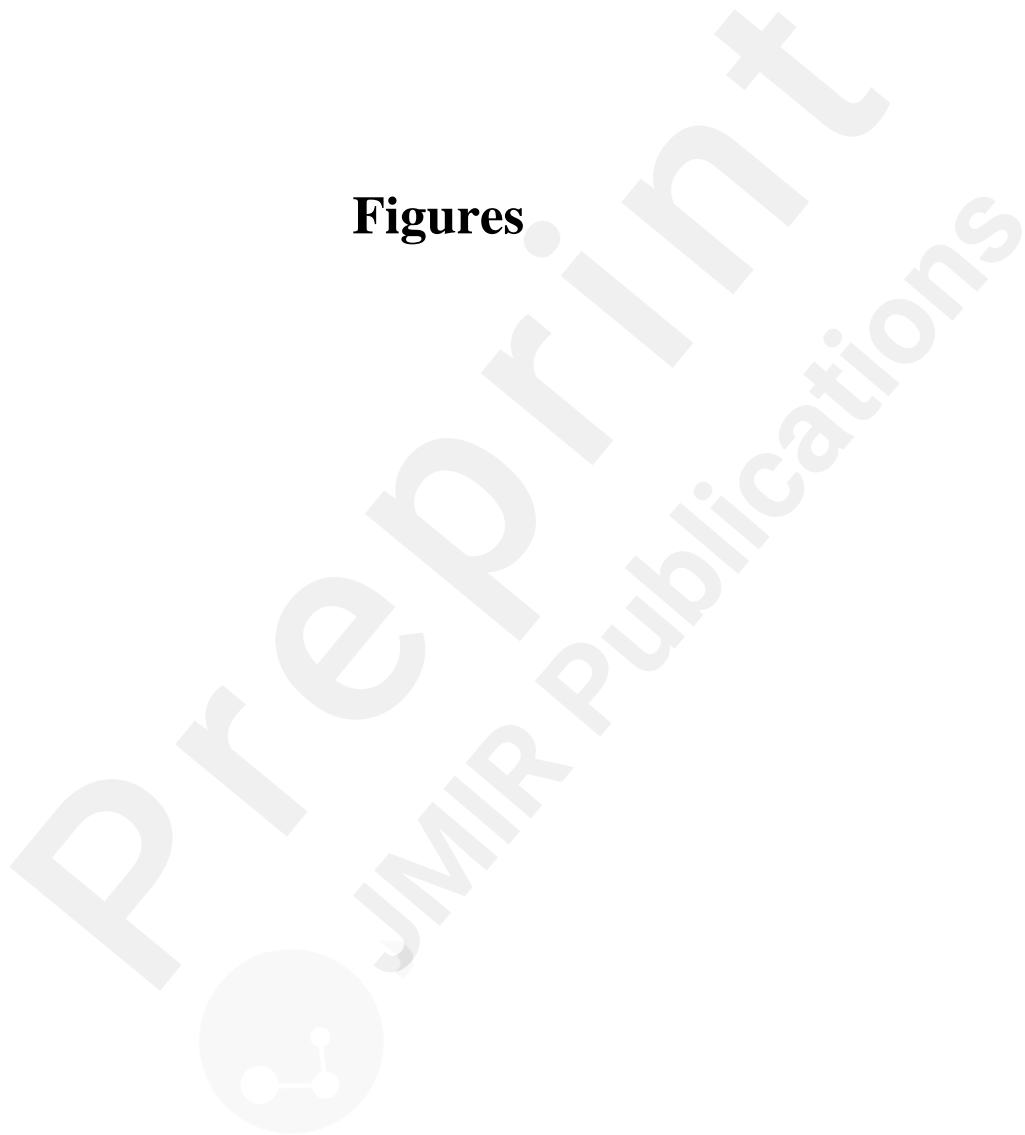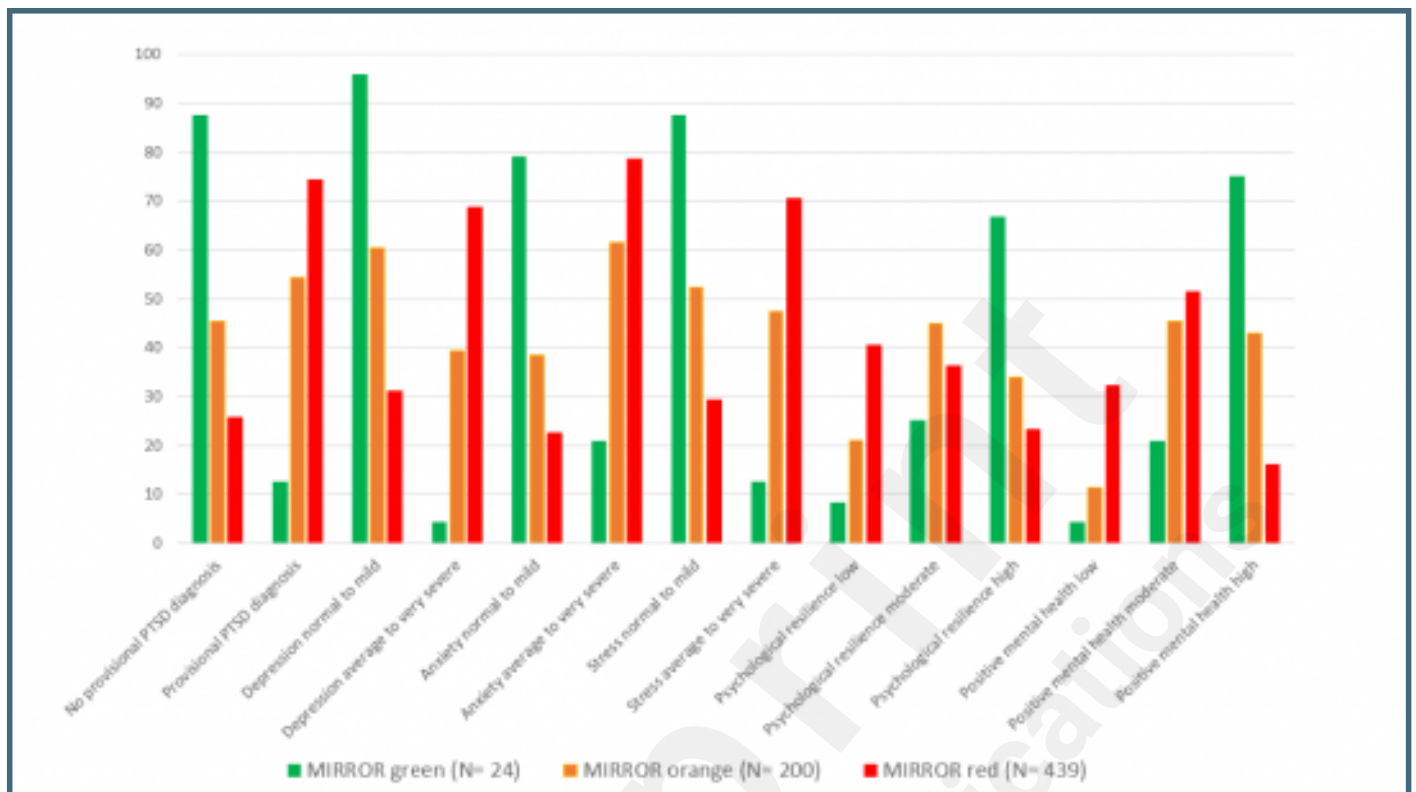
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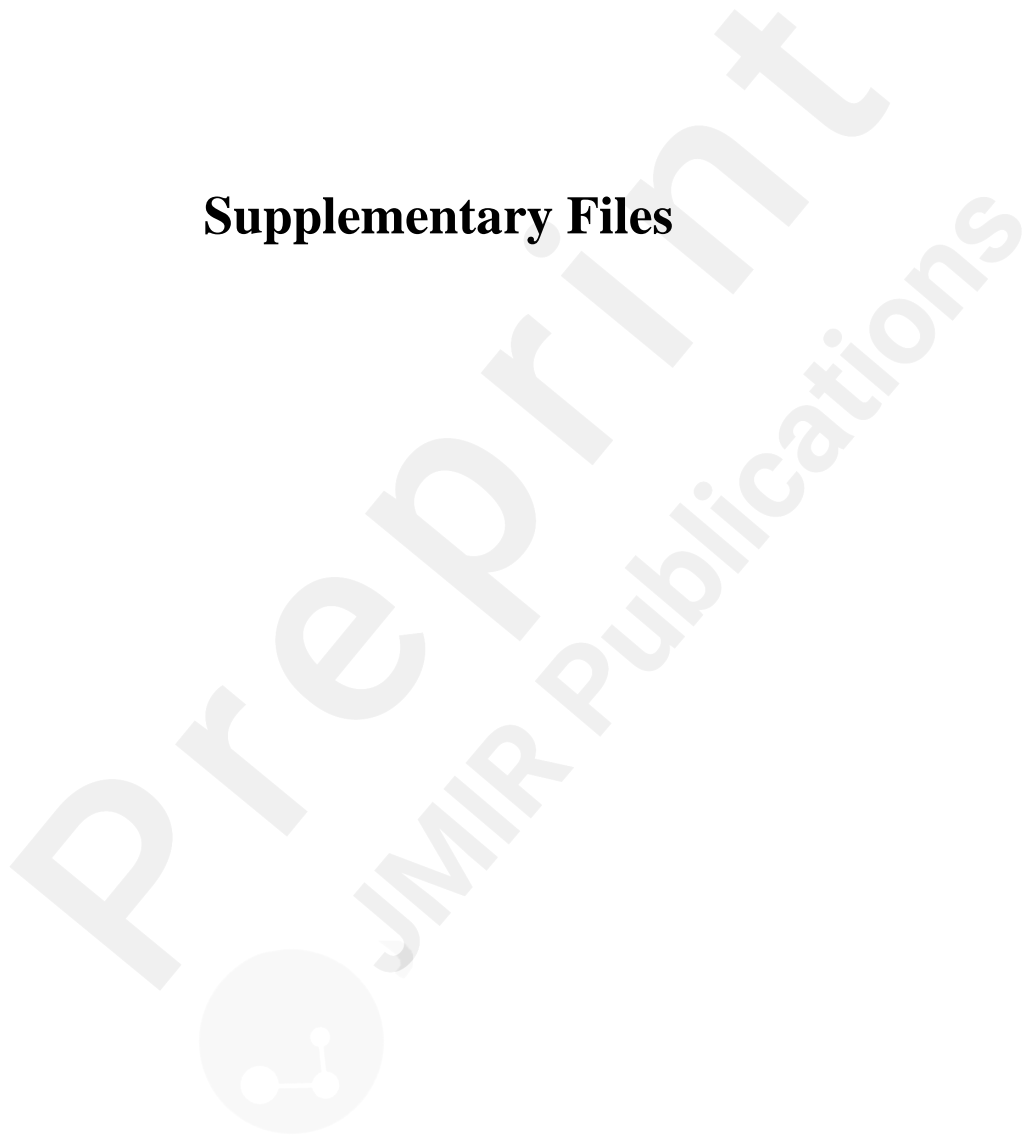
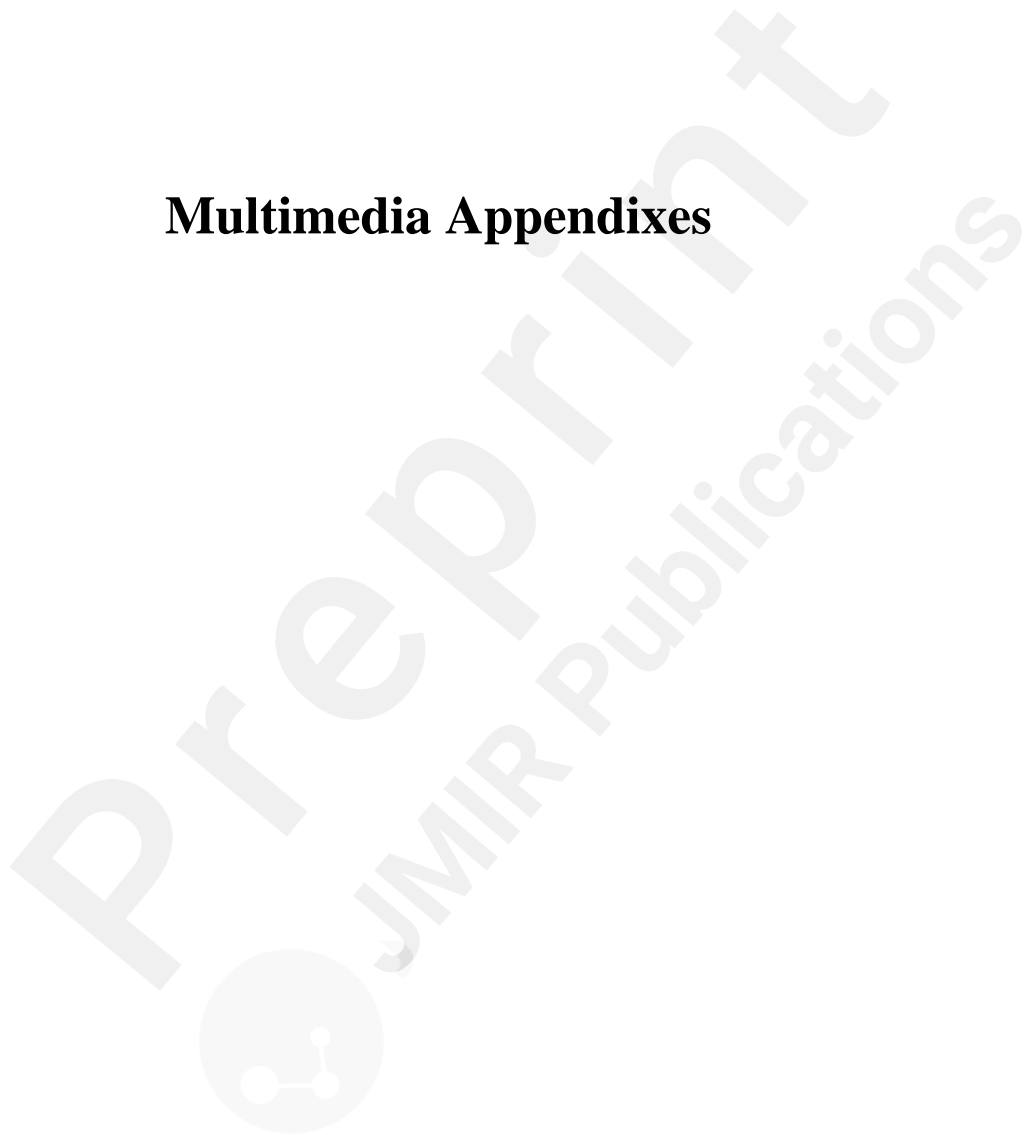# Figures

Classification percentages on reference measures of each MIRROR outcome category.

Multimedia Appendixes

Overview of MIRROR's outcomes.
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Sample characteristics on reference measures and demography (N = 663).
URL: https://asset.jmir.pub/assets/f135e6c69a78e5aa26253d50d1abd991.docx