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Original Article

Development and validation of a Smartphone Impact Scale among healthcare professionals

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الملخص

أهداف البحث: أصبح الاستخدام المفرط للهواتف الذكية سائدا بين المتخصصين في الرعاية الصحية. لم يتم تطوير مقياس متاح لقياس تأثير استخدام الهواتف الذكية وتأثيره على المتخصصين في الرعاية الصحية. ولهذا، تهدف هذه الدراسة إلى تطوير مقياس صالح وموثوق به، لقياس تأثير الهاتف الذكي يمكن استخدامه بين المتخصصين في الرعاية الصحية.

طرق البحث: تم تطوير أداة عامة لدراسة تأثير استخدام الهواتف الذكية بين المتخصصين في الرعاية الصحية. وتم تطوير الخصائص النفسية لـه باستخدام مؤشر صلاحية المحتوى، وطريقة تحليل العوامل، والاتساق الداخلي، وتحليل موثوقية اختبار وإعادة الاختبار. شارك بالدراسة ١٤٣٦ متخصصا في الرعاية الصحية من مناطق مختلفة في المملكة العربية السعودية من خلال استبيان عبر الإنترنت من يناير إلى مايو ٢٠١٩.

النتائج: تم اختيار مقياس مكون من ٢٣ عنصر لتحليل الموثوقية والصلاحية. وكان متوسط مؤشر صلاحية المحتوى ٠.٨٢٤. كان الاتساق الداخلي مع قيمة ألفا كرونباخ ٠.٩١ وموثوقية اختبار إعادة الاختبار ٠.٨٥. بعد تحليل العوامل، تم الانتهاء من المقياس باستبيان مكون من ٢٣ بندا. وكانت قيمة ألفا كرونباخ للعامل الأول ٠.٨٧٥ والعامل الثاني كان ٠.٨٠٣. كما كانت مؤشرات تحليل العوامل المؤكدة كما يلي: متوسط مربع الجذر التقريبي = ٠.٠٧١٠، ومؤشر الملاءمة المقارن = ٠.٨٦١، ومؤشر تكر لويس= ٠.٨٤٥، ومعامل التحديد = ٠.٩٦٩ وكان الارتباط بين عاملين ٠.٦٦.

الاستنتاجات: يتمتع مقياس تأثير الهاتف الذكي بهيكل ثلاثي العوامل وخصائص سيكومترية جيدة. نظرا لأنه يتمتع بالموثوقية والصلاحية الكافية، ويمكن استخدامه بكفاءة لتقييم تأثيرات الهواتف الذكية على المتخصصين في الرعاية الصحية.

الكلمات المفتاحية: أخصائي الرعاية الصحية؛ المملكة العربية السعودية؛ تطوير المقياس؛ إدمان الهواتف الذكية؛ مقياس الهاتف الذكي

Abstract

Objectives: Smartphone overuse is prevalent among healthcare professionals. There is no standard scale that can measure the impact of smartphone usage on healthcare professionals. This study aimed to develop and validate a tool, the Smartphone Impact Scale (SIS), that can effectively measure the use of smartphone among healthcare professionals.

Methods: We developed a generic instrument to study the impact of smartphone usage among healthcare professionals. A total of 1436 healthcare professionals from various regions of KSA participated in this study through an online questionnaire-based survey. The psychometric properties of the SIS were developed using content validity index (CVI), factor analysis, internal consistency, and test-retest reliability analysis.

Results: A 23-item scale was selected for reliability and validity analysis. The average CVI was found to be 0.824. The internal consistency with Cronbach's alpha value was 0.91, and test-retest reliability was 0.85. The Cronbach's alpha values for Factors 1 and 2 were 0.875 and 0.803, respectively. The confirmatory factor analysis

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indices were as follows: root mean square of approximation = 0.0710, comparative fit index = 0.861, Tucker−Lewis index = 0.845, and the coefficient of determination = 0.969. The correlation between two factors was 0.66. After factor analysis, we developed a final questionnaire with 23 items.

Conclusions: Our SIS showed a three-factor structure and appropriate psychometric characteristics. Due to its adequate reliability and validity, SIS can be conveniently used to evaluate the impact of smartphone usage on healthcare professionals.

Keywords: Healthcare professionals; KSA; Scale development; Smartphone addiction; Smartphone scale

Introduction

Over the last decade, many issues have emerged as a result of advances in technology that can affect healthcare systems. Smartphone use in healthcare settings presents both opportunities and challenges. Smartphone addiction has become a worldwide phenomenon.[1] Hence, both smartphone and Internet addiction have been the focus of many studies as a form of behavioural disorder that shows similarities to substance abuse.[1] Many behavioural science studies range from issues concerning smartphones' problematic use to exploring personal experiences with technology in order to understand its impact in a better manner.[2] Along with the global proliferation of smartphones, likewise, in KSA, the number of smartphone consumers is escalating and is projected to reach more than 19 million during 2018.[3] This was emphasised in a study regarding the use of smartphone among healthcare workers in KSA which showed that an estimated 96.6% of healthcare workers had at least one smartphone.[4] The availability of smartphones combined with the addictiveness of applications can result in harmful outcomes when not used productively. Consequently, problematical smartphone use is a growing public health concern that requires research to determine the extent of harm from (over)use of this technology.

Many measures and scales focusing on smartphone overuse and addiction have been developed to capture smartphone behaviour, such as the Nomophobia Questionnaire (NMP-Q),[5] Smartphone Addiction Scale (SAS),[6,7] Problematic Mobile Phone Use Questionnaire (PMPUQ),[8] Media and Technology Usage and Attitudes Scale (MTUAS),[9] Smartphone Use Questionnaires (SUQ-G&A),[10] and Smartphone Overuse Classification Scale (SOCS).[11] Moreover, some researchers have developed scales that measure smartphone addiction, such as the Chinese Smartphone Addiction Inventory (SPAI),[12] and the Korean Smartphone Addiction Proneness Scale (SAPS).[13] These measures have been developed to assess specific aspects of interactions between human beings and smartphones. Problematic mobile phone use (PMPU) is a worldwide phenomenon linked to the misuse of mobile phones.[6,7] In addition, although studies on the problematic use of smartphones have investigated smartphone dependency and addiction, its estimated prevalence has varied due to the use of different measures and scales.[14,15] Hence, there is a need to develop and validate scales with cut-off points that can assure comparability in healthcare settings.[16−18]

Smartphones offer advanced functionality by enabling users to complete tasks both at the workplace and home.[19] However, many recent studies have revealed that prolonged smartphone usage can provoke health problems such as headaches, impaired concentration, insomnia, and musculoskeletal damage.[20] There is also evidence of the negative effects of smartphone addiction on academic performance.[21] In healthcare settings, the widespread use of these smartphones presents many challenges, such as privacy and security risks, while also causing inattention and providing a source of distraction for the workforce.[22,23] Mistakes and lapses in healthcare settings could have fatal consequences for patient care.[24,25] Hence, it may be prudent to establish policies to guide and regulate the use of smartphones at the workplace in order to prevent abuse and overuse.[26,27] The problematic use of smartphones has become an important issue in the medical industry. However, researching the global impact of smartphone technology on healthcare society remains a challenge and is still in its nascent stage.

Currently, there is a gap worldwide in the literature regarding the current trends of the problematic impact of smartphone use among healthcare system workforces, as there are no available standardised scales to examine this phenomenon. To overcome this gap, this study aimed to develop a valid and reliable self-administered scale (SIS) for healthcare professionals with cut-off points that will assure comparability in healthcare settings. Further, it aimed to examine the psychometric properties of the SIS. This scale will also contribute to assessing the influence of smartphone use on healthcare professionals' natural life, and consequently, on the quality of the healthcare system in KSA. Along with this, the predictive factors associated with harmful smartphone impact among healthcare professionals are identified.

Materials and Methods

Scale development

An extensive literature review was conducted from different sources such as EMBASE, CINHAL, MEDLINE, PubMed, PsycINFO, Web of Science, and Cochrane Library to prepare the preliminary draft of the scale as well as focus group discussions. Based on the literature review, initially, investigators prepared a pool of 60 items related to the impact of smartphone use on various dimensions: problematic use of smartphone; smartphone use and addiction; psychological issues (stress relief, anxiety, worry, anger, irritability, empty feeling, sleep problems) associated with smartphone use; physiological problems associated with smartphone use; consequence of smartphone use on social and personal relationship; policies related to smartphone use at work; problems associated with concentration (distraction) and discharging healthcare responsibilities at work; errors in patient care with smartphone use; smartphone use and patient privacy; efficiency in patient care; smartphone and infection; and smartphone use and career opportunities/progression.

To ensure the relevance of the prepared initial pool of items based on existing literature and generate more culture-specific items from real-life situations, the investigators initiated focus group discussions (FGD) with the proposed population of the present research. After preparing the FGD guide, a total of five sessions were conducted with healthcare providers from various fields such as family and emergency medicine, paediatrics, surgery, psychiatry, clinical psychology, pharmaceuticals, nursing, health education, and respiratory therapy. Each FGD group comprised eight to ten participants (both genders), and each session was ended after saturation was reached of participants' contribution. The FGDs were structured based on the following themes: reasons/purpose for smartphone use, major effect on significant life areas, addiction to smartphone use, and smartphone and healthcare delivery. The information generated from the literature review was integrated with FGD responses. The researchers identified three major, well-defined domains of the impact of smartphone usage on healthcare professionals—the extent of smartphone use, and impact of smartphone use on personal and professional life—based on which 40 items were generated as a preliminary draft of the SIS. After closely scrutinising each item the researchers finalised the preliminary pool of the scale. The preliminary scale was subjected to content validity analysis and thus employed a triangulation methodology to ensure the validity of items in this study.

The content validity of SIS was assessed using the content validity index (CVI) as recommended by Polit and Beck.[28] The CVI of SIS was determined by five experts. The objective of this scale was explained to the experts, who consisted of two psychiatrists (MD), two family physicians (MD), and a psychologist with a doctorate degree. They were asked to review the questions after fully comprehending the terminology. Subsequently, they were asked to select the questions that must be included in the scale to evaluate the impact of smartphones on healthcare professionals to determine the final set of questions. To evaluate content validity, the experts rated the relevance of each item using a 4-point ordinal rating scale (1: 'an irrelevant item', 2: 'unable to assess the relevance without item revision', 3: 'relevant but needs minor alteration', and 4: 'an extremely relevant item'). The actual CVI was a proportion of the items that received a rating of 3 or 4 by the experts. The CVI of SIS was calculated based on the experts' rating. The items were removed from the preliminary pool if the CVI was <0.8, and the preliminary SIS was thus finalised.

The selected items were subjected to pre-testing and item analysis, and the final version of SIS was developed. The SIS was administered to a selected target population of 38 individuals for item analysis, which was performed using Cronbach's alpha statistic to evaluate the internal consistency of the scale. Items with 0.80 or more according to Cronbach's alpha were retained in the preliminary draft of the SIS after determining content validity. The final version of the SIS was administered to a large population to explore the domains and establish the test norms. The construct validity of the scale was established through factor analysis. To evaluate the domains and the factor structure of the SIS, exploratory and confirmatory factor analyses were performed. The 23 items were subjected to exploratory factor analysis (EFA). To determine the validity of test item Bartlett's test of sphericity, the Kaiser-Mayer-Olkin (KMO) test was performed to evaluate validity of the test item. The Kaiser criterion, scree test, and the root mean square error of approximation (RMSEA) were used to determine the appropriate number of factors.

To calculate the reliability index, test-retest reliability was assessed to ensure the consistency of the test score results. The test-retest reliability was measured using Intraclass Correlation Coefficient (ICC) based on the total scores obtained in the two surveys conducted among the 38 participants. The questionnaire was re-issued after a one-month gap. The ICC interprets reliability based on the following criteria: < 0.5 (poor), between 0.5 and 0.75 (moderate), between 0.75 and 0.9 (good), and >0.9 (excellent).

Participants and procedure

A cross-sectional design was used in this study. A total of 1442 healthcare professionals consented to participate in the study. The study participants comprised healthcare professionals registered in the database of the Saudi Commission for Health Specialties (SCFHS), who were working at different hospitals under the Ministry of Health (MOH), Ministry of Education (MOE), and private healthcare sectors in KSA. The participants' details were obtained from the SCFHS to expand the study nationwide. An online personal e-mail invitation with a link to a survey (www.surveymonkey.com) and a description of the research was sent to all healthcare professionals registered under SCFHS. An electronic informed consent form was obtained prior to participation in the study in accordance with the Helsinki Declaration. The participants were selected based on specific criteria: (1) being healthcare professionals with at least six months of work experience and (2) using smartphones during the last six months. The study commenced after obtaining approval from an Institutional Review Board (IRB) and the ethical committee of the College of Medicine, Dar Al Uloom University (DAU). Participation was voluntary, and confidentiality was assured.

Measures

Smartphone Impact Scale (SIS)

The standard protocol of tool development was followed in this study. A 23-item instrument was used to measure the extent of smartphone usage among healthcare workers. Each item was rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The 23 items could be grouped into three dimensions, namely, the extent of smartphone use, and the impact of smartphone use on personal and professional life. A socio-demographic questionnaire survey was also conducted to collect general information about the participants.

Statistical analysis

The collected responses were recorded online and later transferred to the IBM Statistical Package for the Social Sciences (SPSS) software version 22.0. (SPSS ver. 22; IBM Corp./Armonk, NY, USA). Descriptive statistics (frequencies, mean, standard deviation [SD]) were reported to describe the participants' socio-demographic characteristics. To analyse the validity of the scale, researchers examined the CVI and content validity ratio (CVR). To estimate the internal consistency reliability of the tool, Cronbach's alpha was obtained, and an ICC was used for establishing test-retest reliability. To investigate the construct validity of the tool, exploratory as well as confirmatory factor analyses were performed using STATA (version 15.1) software. Out of the total sample size of 1,436, 50% (n = 718) was used for EFA and the remaining 50% (n = 718) for confirmatory factor analysis.[29] As the responses for each item were given on an ordinal scale, we used polychoric correlation for EFA. We used the principal axis factoring method for the initial extraction of factors, followed by orthogonal quartimax rotation. For confirmatory factor analysis, the goodness of fit indices used to assess the degree of fit were RMSEA; <0.08 acceptable, <0.05 excellent,[30,31] Tucker−Lewis index (TLI; >0.90 acceptable, >0.95 excellent),[31] and Bentler's comparative fit index (CFI; >0.90 acceptable, >0.95 excellent).[32]

Results

Socio-demographics of the participants

In total, 1442 participants responded to the study, of whom we excluded those who did not complete the measures (n = 6). The final sample comprised 1436 participants, of whom 862 (60%) were male, and 574 (40%) were female. The analysis of socio-demographic details of the study participants indicates that most of them were males with a mean age of 40.72 years (SD = 9.10 years). The age distribution analysis shows that the majority of the participants were aged between 25 and 45, which constituted 72.4% of the sample. The sample population comprises multinationals, of whom 63.9% were non-Saudi citizens working in the healthcare sector at KSA. The majority of this study's participants were working at hospitals with 17.7% working in a primary health centre, and most worked in the central region of KSA. The sample was generally divided into two categories based on the health professions: physicians (67.5%) and allied health professionals (32.5%). The investigators collected samples from different regions (provinces) of KSA. The study participants representing the different provinces of central, eastern, western, southern, and northern KSA were 45.8%, 12.7%, 26.3%, 8.1%, and 7%, respectively.

Table 1 shows the preliminary item development and its adequacy and importance as rated by five medical health experts. A total of 40 items were pooled and subjected to the expert validation process. A CVI of 0.8 and above was retained in the final form of the SIS. Item numbers 2 and 35 in the preliminary draft were deleted from the pool as experts suggested that the same meaning was conveyed in

Table 1: Preliminary item development, and adequacy and importance rated by expert healthcare professionals.

Pilot item	Included item	Content	CVI	CVR
Q.1	√	I am thinking of shortening my smartphone usage time	1	1
Q.2		My family and friends notice that I am using my smartphone excessively	0.8	0.2
Q.3	√	I cannot control the desire to use my smartphone	1	1
Q.4	√	I get irritated when I am interrupted while using my smartphone	0.8	0.6
Q.5	√	I feel very stressed and worried when my smartphone is not with me	0.8	0.6
Q.6		I always think about my smartphone even if I am not using it	0.6	0.2
Q.7	√	I continuously check my smartphone for updates	0.8	0.6
Q.8	√	Immediately after waking up, I will check my smartphone	0.8	0.6
Q.9	√	I cannot sleep without my smartphone by my side	1	1
Q.10		I feel I am getting addicted to my smartphone	0.6	0.2
Q.11	√	While using my smartphone I feel discomfort in my fingers and wrist	1	1
Q.12	√	While using my smartphone, I feel neck and back pain or discomfort	1	1
Q.13	√	Sharing of patient medical information through smartphones may increase patients' privacy breaches and insecure medical data storage	1	1
Q.14		I feel dizziness and lightheadedness due to excessive smartphone use	0.6	0.2
Q.15	√	I experience eye discomfort or strain due to excessive smartphone use	1	1
Q.16		I experience eating problems due to smartphone use	0.6	0.2
Q.17	√	I experience sleeping problems due to smartphone use	1	1
Q.18		I experience hearing problems or ear pain due to smartphone use	0.6	0.2
Q.19	√	I experience distraction and memory problems due to smartphone use	0.8	0.6
Q.20		I feel as if life is empty without my smartphone	0.6	0.2
Q.21	√	I feel very excited while using my smartphone	1	1
Q.22		I feel pain as if I have lost a friend if I am unable to use my smartphone	0.6	0.2
Q.23	√	I feel very lonely without my smartphone	1	1

Table 1 (*continued*)

Pilot item	Included item	Content	CVI	CVR
Q.24	√	I get relief from all stress and tension when I am using my smartphone	1	1
Q.25	√	I am always worried that I will lose my smartphone	1	1
Q.26	√	I feel sad when I am not receiving any messages or communications	1	1
Q.27	√	I feel that my connections with smartphone friends are closer than with my real-life friends	1	1
Q.28		I prefer talking to smartphone friends rather than socialising with real-life friends	0.6	0.2
Q.29	√	Smartphone use at work will increase the contamination risk	1	1
Q.30		Due to smartphone use, I am unable to listen effectively to my social circle	0.4	−0.2
Q.31	√	I am unable to complete planned daily work due to smartphone use	1	1
Q.32	√	Smartphone use will increase medical errors in clinical care	1	1
Q.33		I am unable to focus on career progression due to smartphone use	0.4	−0.2
Q.34	√	I am facing conflicts with my colleagues at work due to smartphone use	1	1
Q.35		I am unable to keep my smartphone away from me when I am at work	0.8	0.6
Q.36		I am unable to provide quality time to focus on my professional activities	0.4	−0.2
Q.37		Smartphone use is an obstruction to maintaining a team relationship with my colleagues	0.4	−0.2
Q.38		I favour searching for medical information through smartphones	0.4	−0.2
Q.39		Smartphone use at work will reduce medical errors and inefficiencies	0.4	−0.2
Q.40		Smart phones are helpful for patient care	0.4	−0.2

other items. Based on the experts' recommendations and rating, 23 out of 40 questions were selected to be included in the final SIS scale.

Internal consistency reliability and test-retest reliability

The 23 selected items from the preliminary draft were subjected to reliability analysis to calculate the internal consistency of the scale. The scale was administered to 38 individuals selected from the healthcare field. The data were collected and analysed using Cronbach's alpha reliability test, and the scale was found to have good internal consistency with Cronbach's alpha value of 0.91. The analysis indicates that the Cronbach's alpha value of the total scores of all 23 items was 0.8 and above; thus, investigators retained all 23 items for the standardisation of the final scale. The scale's item dimensions based on the preliminary draft were as follows:

Table 2: Item analysis of SIS (N = 38).

Q.No.	Scale mean if item deleted	Scale variance if item deleted	Corrected item−total correlation	Cronbach's alpha if item deleted
Q.1	69.1842	175.235	0.488	0.886
Q.2	68.7632	179.267	0.625	0.884
Q.3	68.5526	180.957	0.380	0.889
Q.4	68.5263	174.148	0.630	0.882
Q.5	68.3947	175.813	0.606	0.883
Q.6	68.7368	178.091	0.488	0.886
Q.7	68.8947	178.908	0.494	0.886
Q.8	70.0263	201.161	-0.286	0.904
Q.9	68.3947	175.164	0.511	0.886
Q.10	68.8947	171.718	0.649	0.882
Q.11	69.2105	178.009	0.491	0.886
Q.12	69.1053	173.178	0.707	0.881
Q.13	68.2632	176.740	0.646	0.883
Q.14	68.8421	172.839	0.603	0.883
Q.15	68.4211	185.764	0.234	0.892
Q.16	69.3684	181.861	0.353	0.890
Q.17	68.3684	179.266	0.564	0.885
Q.18	69.4474	173.821	0.628	0.882
Q.19	68.8684	174.712	0.558	0.884
Q.20	68.8684	176.820	0.478	0.886
Q.21	69.0526	173.349	0.536	0.885
Q.22	69.2895	186.644	0.196	0.894
Q.23	69.1053	175.232	0.647	0.882

- Extent of smartphone use: 1, 3, 4, 5, 7, 8, 9, 21, 23, 24, 25, 26, 27
- Impact of smartphone use on personal life: 11, 12, 15, 17, 19
- Impact of smartphone use on professional life: 13, 29, 31, 32, 34

Table 2 depicts the item analysis after internal consistency reliability analysis. The 23 selected items were shuffled before administering the scale to the subjects for standardisation. The total SIS score, which ranged from 23 to 115, was calculated by summing the scores of each dimension.

The test-retest reliability was assessed using ICC based on the total scores obtained in the two surveys conducted among the original 38 participants. The second survey was conducted after a gap of one month. The value of ICC for a two-way mixed effects model using single measure absolute consistency was 0.85 (95% CI − 0.74, 0.92).

Construct validity

The significance of Bartlett's test of sphericity ($\chi 2$ [df = 253] = 9675.84, $p < 0.001$) and the KMO results (=0.933) suggested that factor analysis was appropriate for these data. The Kaiser criterion, scree test (Figure 1), and the

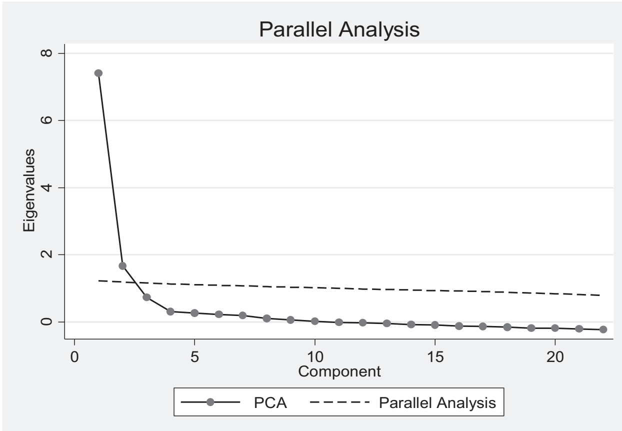

Figure 1: Scree Plot of Eigen values for the Smartphone Impact Scale.

RMSEA were used to determine the appropriate number of factors. In the exploratory analysis of 23 items, items 8 and 15 did not fit under any factor, and hence, were removed from further analysis. The remaining 21 items were subjected to EFA and loaded on to three factors that explained 86.8% of the variation in the data. The proportions of variation explained by these three factors were 51.8%, 27.7%, and 7.3%, respectively. Each of the remaining factors explained less than 3% of the variability. Table 3 gives the rotated factor loading for each item under these three factors; loadings less than 0.4 are suppressed.

The EFA suggested three factors: Factor 1 (extent of smartphone use) and Factors 2 and 3 (impact of smartphone use on personal and professional life, respectively). Factor 3, however, was incorporated into Factor 2, as the two had similar characteristics. According to the experts' recommendation, Items 8 and 15 were relevant to evaluate the impact of smartphone use among healthcare providers; thus, investigators were forced to retain them, and the total number of 23 SIS items remained. The rotated factor loadings for Item 18 under Factor 1 and Factor 2 were 0.354 and 0.340, respectively. After accepting the two-factor solution, each item's factor loading was examined. The Cronbach's alpha values for Factors 1 and 2 were 0.875 and 0.803, respectively. The final Factor 1 items were 2, 4, 5, 7, 9, 10, 12, 14, 16, 17, 20, 21, and 22, while Factor 2 items were 1, 3, 6, 8, 11, 13, 15, 18, 19, and 23. The confirmatory factor analysis was conducted to evaluate the two-factor (21-item) scale. In the confirmatory factor analysis, the overall goodness of fit indices were as follows: RMSEA = 0.0710, CFI = 0.861, TLI[31] = 0.845, and the coefficient of determination = 0.969. The correlation between the two factors was 0.66 (95% CI: 0.61, 0.70). Table 4 presents the standardised factor loadings based on confirmatory factor analysis.

Table 3: Rotated factor loadings using orthogonal quartimax rotation.

Item order	Item order of preliminary draft	Factor 1	Factor 2	Factor 3
Q1	Q.17		0.431	
Q2	Q.21	0.487		
Q3	Q.12		0.722	
Q4	Q.23	0.752		
Q5	Q.7	0.696		
Q6	Q.15		0.664	
Q7	Q.4	0.563		
Q9	Q.8	0.682		
Q10	Q.3	0.738		
Q11	Q.9		0.757	
Q12	Q.29	0.470		
Q13	Q.1		0.406	
Q14	Q.25	0.487		
Q16	Q.26	0.604		
Q17	Q.5	0.733		
Q18	Q.31			0.511
Q19	Q.11		0.644	
Q20	Q.9	0.658		
Q21	Q.27	0.516		
Q22	Q.24	0.638		
Q23	Q.19		0.461	

The category score of the SIS

The total SIS score was calculated by summing the scores of each item; it ranged from 23 to 115, with higher scores corresponding to higher smartphone usage and its negative impacts. The descriptive analysis of the total score of smartphone use indicates that the range was 84, and the mean score of total smartphone use was found to be 65.73 (13.58). This study identified the cut-point(s) of the scale for detecting the biopsychosocial significant warning sign. Based on the percentile score, the total score of the SIS can be categorised into normal use, and mild, moderate, or severe impact. Scores lower than or equal to 66 were considered to reflect normal use of the smartphone. Scores ranging between 67 and 74 reflected a mild impact of smartphone use; those ranging between 75 and 84 reflected a moderate impact; and scores of 85 and above reflected a severe impact of smartphone use.

For the individual domain of the extent of smartphone use (minimum score 13, maximum 65), a total score of 38 or less indicates normal use of a smartphone (positive); a score between 39 and 45 indicates mild negative impact and requires attention; a score between 46 and 50 indicates moderate negative impact and [the] 'need for action'; and scores of 51 and above indicate severe impact and 'needs professional help'. For the domain of impact of smartphone use on personal life (minimum score 5, maximum 25), a total score of 14 or less indicates normal; a score between 15 and 17 indicates mild negative impact and 'needs attention'; that between 18 and 20 indicates moderate negative impact and 'need for action'; and scores of 20 and above indicate severe impact and 'needs professional help'. Finally, in the domain of impact of smartphone use on professional life (minimum score 5, maximum 25), a total score of 14 or less indicates a strong positive impact; a score between 15 and 16 indicates mild negative impact and 'needs attention'; that between 17 and 18 indicates moderate negative impact and 'need for action'; and scores of 19 and above indicate severe impact and 'needs professional help'.

Table 4: Confirmatory factor analysis and standardised factor loadings of each item (N = 718).

SIS order	Preliminary draft	Item	Factor loading
Q1	Q.17	I experience sleeping problems due to smartphone use	0.574
Q2	Q.21	I feel very excited while using my smartphone	0.505
Q3	Q.12	While using my smartphone, I feel neck and back pain or discomfort	0.653
Q4	Q.23	I feel very lonely without my smartphone	0.651
Q5	Q.7	I continuously check my smartphone for updates	0.583
Q6	Q.15	I experience eye discomfort or strain due to excessive smartphone use	0.662
Q7	Q.4	I get irritated when I am interrupted while using my smartphone	0.607
Q8	Q.32	Smartphone use will increase medical errors in clinical care	
Q9	Q.8	Immediately after waking up, I will check my smartphone	0.560
Q10	Q.3	I cannot control the desire to use my smartphone	0.706
Q11	Q.13	Sharing of patient medical information through smartphones may increase patients' privacy breaches and insecure medical data storage	0.731
Q12	Q.1	I am thinking of shortening my smartphone usage time	0.573
Q13	Q.29	Smartphone use at work will increase the contamination risk	0.419
Q14	Q.25	I am always worried that I will lose my smartphone	0.507
Q15	Q.34	I am facing conflicts with my colleagues at work due to smartphone use	
Q16	Q.26	I feel sad when I am not receiving any message or communications	0.603
Q17	Q.5	I feel very stressed and worried when my smartphone is not with me	0.645
Q18	Q.31	I am unable to complete planned daily work due to smartphone use	0.461
Q19	Q.11	While using my smartphone I feel discomfort in my fingers and wrist	0.636
Q20	Q.9	I cannot sleep without my smartphone by my side	0.588
Q21	Q.27	I feel that my connections with smartphone friends are closer than with my real-life friends	0.552
Q22	Q.24	I get relief from all stress and tension when I am using my smartphone	0.559
Q23	Q.19	I experience distraction and memory problems due to smartphone use	0.575

Table 5: The Smartphone Impact Scale (SIS): The following questions are about smartphone usage and certain experiences that you may have while using your smartphone. We are interested in how frequently you have these experiences on a typical day.

DOMAIN 1	Extent of Smartphone use	
	1. Q2	I feel very excited while using my smartphone
	2. Q4	I feel very lonely without my smartphone
	3. Q5	I continuously check my smartphone for updates
	4. Q7	I get irritated when I am interrupted while using my smartphone
	5. Q9	Immediately after waking up, I will check my smartphone
	6. Q10	I cannot control the desire to use my smartphone
	7. Q12	I am thinking of shortening my smartphone usage time
	8. Q14	I am always worried that I will lose my smartphone
	9. Q16	I feel sad when I am not receiving any message or communications
	10. Q17	I feel very stressed and worried when my smartphone is not with me
	11. Q20	I cannot sleep without my smartphone by my side
	12. Q21	I feel that my connections with smartphone friends are closer than with my real-life friends
	13. Q22	I get relief from all stress and tension when I am using my smartphone
DOMAIN 2	**Impact of smartphone use on Personal life**	
	1. Q1	I experience sleeping problems due to smartphone use
	2. Q3	While using my smartphone, I feel neck and back pain or discomfort
	3. Q6	I experience eye discomfort or strain due to excessive smartphone use
	4. Q19	While using my smartphone I feel discomfort in my fingers and wrist
	5. Q23	I experience distraction and memory problems due to smartphone use
DOMAIN 3	**Impact of smartphone use on Professional life**	
	1. Q8	Smartphone use will increase medical errors in clinical care
	2. Q11	Sharing of patient medical information through smartphones may increase patients' privacy breaches and insecure medical data storage
	3. Q13	Smartphone use at work will increase the contamination risk
	4. Q18	I am unable to complete planned daily work due to smartphone use
	5. Q15	I am facing conflicts with my colleagues at work due to smartphone use

Table 5 showed the SIS questions which are with regard to smartphone usage and certain experiences that the healthcare professional may have while using their smartphone.

Discussion

This study was conducted to broaden the view of healthcare professionals' interactions with smartphones, which, in the existing literature, lacked proper measurement. The study aimed to develop a valid and reliable self-administered scale—the SIS—that could be used to address the impact of smartphones on the quality of the healthcare system. Thus, it identified the developmental process of the SIS and explored its psychometric properties. The analysis of the SIS dimensionality and its subscales demonstrated good reliability and validity in evaluating the impact of smartphone usage among healthcare providers. This scale, which comprises 23 items rated on a five-point Likert scale (1: 'strongly disagree' to 5: 'strongly agree'), measured two dimensions of smartphone impact. The first dimension addresses the scope of smartphone use and the associated negative, cognitive, and emotional reactions. The second dimension addresses the consequence of smartphone use on personal and professional aspects of users, including the awareness of its negative impacts on daily life. These dimensions showed meaningful associations with a series of biopsychosocial constructs related to human interactions with smartphones.[33−35] Awareness of the negative impacts of smartphones enables the investigation of paths to avoid these negative consequences.

The standardisation sample of this study was representative, as it included a total of 1436 healthcare professionals from different regions of KSA. This study has a large number of participants in comparison with other standardisation samples from existing scales such as SAS,[6,7] PMPUQ,[8] SUQ-G&A,[10] and SOCS.[11] In this study, the validity of the scale was established through expert FGD and by determining the CVI as a standard protocol for its development. As the literature was not sufficiently rich to provide a comprehensive conceptual framework of the proposed study, the investigators adopted expert FGD and a biopsychosocial model to develop the preliminary test items.[36,37] This generated a wide range of items included on the SIS based via a thorough literature review and FGD. This is similar to the process of development of the SOCS,[11] in which Ding and his team conducted two sessions of FGD to identify the items of the scale. According to the guidelines outlined by Yusoff[28] the CVI was calculated for individual items, the I-CVI was more than 0.8, and the overall item CVI was 0.82, which is within the accepted standard. This study proved good internal consistency of the SIS with Cronbach's alpha value of 0.91. Kwon et al.[7] also reported a higher score of SAS (Cronbach's alpha = 0.96) in internal consistency and concurrent validity. Similar to the results of the PUMP Scale,[38] the SIS demonstrated excellent internal consistency (0.94). These data support the validity and reliability of SIS for use in research to examine the impact of smartphone use in healthcare facilities.

Factor analysis was also implemented, and its analysis procedure was consistent with processes that had been followed in other studies.[5−7] The results from the EFA suggested two factors. The first factor, 'the extent of smartphone use by healthcare professionals', was defined as follows: feeling excited while using a smartphone; feeling very lonely without it; continuously checking it for updates; getting irritated when interrupted while using it; immediately checking it after waking up; being unable to control the desire to use it; thinking of shortening its usage time; being constantly worried about losing it; feeling sad when not receiving any message or communication; feeling stressed and worried when it is not with the user; being unable to sleep without the smartphone nearby; feeling that one's connections with smartphone friends are closer than those with real-life friends; and feeling relieved from stressors and tension when using the smartphone. Smartphone users recognise not only its crucial scope in their daily lives but also its emotional and psychological influence. The first dimension of this study corresponded with the findings of the items and dimensions concerning the Smartphone Addiction Scale (SAS).[7] The SAS is a unidimensional instrument designed to measure multiple items and factors related to smartphone addiction and its impact on health and social impairment, isolation, daily life disturbance, withdrawal, overuse, and tolerance. Similarly, the items of the first dimension of SIS were strongly associated with dimensions and items contained in the Nomophobia Questionnaire (NMP-Q).[5] These items include behaviours related to the fear of not being able to use smartphones nor interact, especially in terms of anxiety and stress symptoms. It was established that the first dimension of this study captures contextualised interactions of healthcare professionals with their smartphones that trace dependence attitudes and anxiety and stress behavioural feelings. Moreover, the first dimension of the SIS scale showed meaningful associations with a series of psychosocial constructs related to SAS and NMP-Q. However, it is noteworthy that the aforementioned studies were conducted on samples of college students or adolescents, which differs from this study's population.

The second factor includes two diverse perspectives: first is 'the impact of smartphone use on the personal life of healthcare professionals', while the second is 'the impact of smartphone use on the professional life of healthcare professionals'. Compared with existing measures,[38,39] the second factor of SIS measures the negative impacts of smartphone use on healthcare professionals from a different perspective. It addresses other perceptions of smartphone use that are not derived from existing measures. This factor included the following characteristics: experiencing sleeping problems; feeling discomfort in the fingers or wrist; feeling pain in the neck and back; suffering from eye discomfort or strain; facing distractions and memory problems; being unable to complete planned daily work due to smartphone use; noticing an increase in medical errors in clinical care, in patients' privacy breaches and unsafe medical data storage, and contamination risk; and facing conflict with other colleagues. Smartphone users experience physical as well as professional harmful consequences as a result of its excessive use. The second factor of this study was consistent with some elements and items of a study by Pancani and Preti[39] on measures concerning awareness of the negative impacts of smartphones. In this context, several previous descriptive studies have noted the negative impacts of smartphones in healthcare facilities.[22–27] One such study suggested that ethical and legal regulations in the use of these smartphones in healthcare facilities should be developed to limit their abuse,[40] as they found that 40% of healthcare employees were uneducated about their workplace policy, which could potentially cause distraction or privacy breach of confidential healthcare data. Furthermore, other studies have found that only 31% of healthcare institutions have a social media policy.[40,41] This is worrying because executing policies regarding personal smartphone use during work hours is vital in protecting confidential medical information and preventing distractions. The findings regarding this factor analysis also agree with those of other studies, which revealed that smartphones at healthcare facilities risked distraction and microbial transmission, as their microbial load has been documented in various researches.[27,42,43] Thus, considering the items and measures of the second factor of SIS could help narrow down the harmful use of these devices by identifying those who are at risk to its harmful effects on healthcare professionalism. However, no existing scales have been developed to measure the potential harmful consequences of smartphone use among healthcare professionals. Therefore, the major strength of this study is considered to be the scale (SIS). The construct underlying the SIS tool displayed its validity when compared to an existing measure of smartphone addiction and misuse.[7,11,38] These data provide support for its use in research examining problematic smartphone use in healthcare institutes, as it could be a good strategy to assess healthcare professionals' awareness of the magnitude of negative outcomes resulting from the overuse of smartphones.

All these items and factors analysis indicate that the SIS was validated to measure the level of the impact of smartphones on healthcare professionals with high reliability and validity. Thus, using this SIS as a screening tool could help to recognise and minimise such harmful impacts in healthcare settings. Plans should be made to measure and prevent the negative impacts of smartphone use in the daily lives of healthcare professionals. Nevertheless, this study has some limitations. The sample was selected conveniently, and investigators could not adopt any other probability sampling method. As a self-report questionnaire survey was conducted, the researcher was unable to adopt any method in scale development to reduce insincere responses. This study was not able to perform any concurrent validity analysis. The lack of not only an objective measure of smartphone use but also specific diagnostic guidelines was an impediment to establishing a generic test norm. With the evolutionary nature of smartphones and advancements in medical applications, future research could include other scales with a multifactorial nature. Despite these limitations, the SIS underwent a systematic development and standardisation process and was demonstrated to be a valid and reliable self-report scale that can account for the various impacts of smartphones on everyday life. Additionally, the implications drawn from the results of this study expand the understanding of smartphone-related negative impacts on healthcare settings. Accordingly, the authors expect that this scale can be used efficiently to design and implement guidance programmes to ensure optimum use of smartphone devices and their functionalities among healthcare professionals to enhance the quality of the healthcare system.

Conclusions

This study developed a reliable and valid self-report scale—SIS—that measures the negative impacts of smartphone use in the healthcare environment. The SIS introduced new factors and a biopsychosocial construct of the smartphone interactions of healthcare professionals. From the perspective of practical application, this scale could be adopted in healthcare settings to explore the potential risks of smartphone misuse in the healthcare system. In healthcare organisational settings, the SIS might be useful to determine the boundary between helpful and harmful impacts of smartphone devices. Policy guidance is needed to plan its harmful reduction strategies; thus, the current scale will help healthcare policymakers to develop legal regulations and policies that manage the utilisation of the benefits of those technologies with organisational security and patient privacy.

Recommendations

The awareness of the harmful usage of smartphone in healthcare facilities could assist the limitation of its negative impacts. Hence, the SIS could measure the potential harmful impacts on healthcare professionals from smartphone abuse, including social, physical, occupational, and psychological concerns, and it will be useful to identify these harmful impacts as targets for future prevention and intervention. Future studies are also recommended in other Arabic speaking societies to verify the SIS reliability and validity and support the results of this study. Further studies using SIS on the impact of smart phone use on healthcare quality in KSA are recommended to identify those at risk of the negative impacts of the smartphone, to minimise its dysfunctional use in healthcare settings. Moreover, considering the ethnic background of the participants, future studies could reflect a pattern of usage based on the cultural background of the participants.

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Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

This study was approved by the Institutional Review Board and ethical committees and was conducted in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Authors contributions

TNA reviewed the literature, design of the study, conceptualization, methodology, data collection, interpretation of the data and writing the original draft and approved the final draft, and funding acquisition, JJA and BVS also designed the study, analysis and interpretation of the data and software validation, and JJA and MMK did the literature review, design of the study, interpretation of the data and writing-reviewing and editing. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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