

Supplementary Materials

Table S1. Summary of Study Characteristics–Pain Management Mobile Applications aspects of design concerns.

Author & Year	Pain Type	Targeted Population (Age, Gender, Technology Literacy level of the study participants)	Outcome measures	Technology (Device, Platform & Technique)	Data Input mode	Frequency of Data Input	Data input Method	Types of Assessment
Serif, T., & Ghinea, G. (2005) [38]	chronic back pain	27–65 years, both male and female, literacy level not mentioned	pain type, location and intensity	PDA; Windows CE; Internet Technology & Mobile Computing	active	every 2 hours between 10am to 4pm 4 times a day	1. Pain drawing 2. Visual analogue scale 3. Open Answers	static & standard
Stinson, J. N., Petroz, G. C., Tait, G., Feldman, B. M., Streiner, D., McGrath, P. J., & Stevens, B. J. (2006) [44]	chronic pain of juvenile idiopathic arthritis	9-18 years, both male and female, 90% aware with technology	pain intensity stiffness and fatigue	PDA, palm operating system; Internet Technology & Mobile Computing	active	three times a day	1. VAS Slider 2. Pain drawing	dynamic & standard
Kearney, N., Kidd, L., Miller, M., Sage, M., Khorrami, J., McGee, M., ... & Gray, P. (2006) [58]	cancer pain	24–77 years, both male and female, literacy level not mentioned	pain and associated symptoms fatigue, nausea and vomiting, oral problems, diarrhea and breathlessness depending on diagnosis	handheld computer; web based and flexible to use on hand held PCs; Internet Technology & Mobile Computing	active	not mentioned	Multiple choice questions	static & standard
Sorbi, M. J., Mak, S. B., Houtveen, J. H., Kleiboer, A. M., & van Doornen, L. J. (2007) [40]	chronic migraine	34-52 years, female, literate, working professionals and have knowledge of technology	(1) migraine headache and medication use, (2) attack precursors, and (3) self-relaxation and other preventive behavior; in addition, menstruation and disturbed sleep is monitored.	PDA; palm operating system; Internet Technology & Mobile Computing	active	1st run 4-5 times a day 2nd run 2-3 times a day	1. Multiple Choice 2. Visual Analogue Scales 3. Open answers	static & standard
Anatchkova, M. D., Saris-Baglama, R. N., Kosinski, M., & Bjorner, J. B. (2009) [23]	Chronic Pain	>=18 years, both male and female, literacy level not mentioned	pain severity	tablet PC; Microsoft XP Tablet Edition operating system; Internet Technology & Mobile Computing & Advanced Algorithms	active	not mentioned	Visual rating scales	dynamic & standard
McClellan, C. B., Schatz, J. C., Puffer, E., Sanchez, C. E., Stancil, M. T., & Roberts, C. W. (2009) [34]	chronic vaso-occlusive pain (sickle cell disease)	8–20 years, both male and female, literacy level not mentioned	daily pain report	Motorola Q Smartphone; windows mobile; Internet Technology & Mobile Computing	active	average 2 times a day	1. numerical rating scale 2. Multiple choice questions	static & standard

Luckmann, R., & Vidal, A. (2010) [24]	non cancer Chronic Pain	Age not specified, gender not specified, literacy level not mentioned	routine pain, activity, medication and non-medication treatment	PDA (iPaq - pocket PC); windows mobile operating system; Internet Technology & Mobile Computing	active	enter data every 2–4 h	Multiple choice question (questions to answer with suitable option from a response set)	static & customized
Hachizuka, M., Yoshiuchi, K., Yamamoto, Y., Iwase, S., Nakagawa, K., Kawagoe, K., & Akabayashi, A. (2010) [26]	cancer pain	>=20 years, both male and female, none had previously used PDA or computer	pain intensity	PDA; palm operating system; Internet Technology & Mobile Computing	active	average 3 times a day additional on taking rescue medicine	visual analogue scale	static & standard
Rosser, B. A., McCullagh, P., Davies, R., Mountain, G. A., McCracken, L., & Eccleston, C. (2011) [15]	chronic pain	Age not specified, both male and female, familiar with computing and mobile technology	pain intensity mood other experimental variables	Mobile device - HTC smartphone HomeHub (static touch screen computer) - eeeTop Asus; Windows mobile 6.5 OS; Internet Technology & Mobile Computing	hybrid smartphone app and an inbuilt accelerometer and Global positioning System (GPS) technology to cooperatively monitor the individual's physical activity.	not mentioned	Numeric rating scale	static & customized
Jacob, E., Stinson, J., Duran, J., Gupta, A., Gerla, M., Lewis, M. A., & Zeltzer, L. (2012) [35]	chronic pain in sickle cell disease	10-17 years, both male and female, literacy level not mentioned	pain and associated symptoms tiredness, headache, coughing, fatigue	Smartphone; platform not mentioned; Internet Technology & Mobile Computing & Web Technology	active	pain experience in last 12 hours	1. visual analogue scale 2. body outline diagram 3. multiple choice question 4. free text question	static & standard
Spyridonis, F., Grønli, T. M., Hansen, J., & Ghinea, G. (2012) [46]	body pain in wheelchair patients (musculoskeletal pain)	>=18 years, both male and female, literacy level not mentioned	pain type and location (not even intensity, only to record pain variation with time)	smartphone and tablets; android; Internet Technology & Mobile Computing & Virtual Reality	active	not mentioned	body outline diagram / pain drawing	static & standard
Baggott, C., Gibson, F., Coll, B., Kletter, R., Zeltzer, P., & Miaskowski, C. (2012) [27]	cancer pain	13-21 years, both male and female, participants had basic computer and mobile phone literacy	pain, nausea, vomiting, fatigue and sleep quality	smartphone – iPhone; iOS; Internet Technology & Mobile Computing	active	single daily report to avoid patient burden	1. body diagram 2. color analog scale (visual analog scale) 3. Face pain scale	static & standard
Stinson, J. N., Jibb, L. A., Nguyen, C., Nathan, P. C., Maloney, A. M.,	cancer pain	9-18 years, both male and female, literacy level not mentioned	sensory, effective and evaluative nature of pain as well as questions related to pain	smartphone – iPhone; Apple iOS - client side Ibatis.NET - server side	active	twice a day	1. visual analogue slider (dimensions of pain)	static & standard

Dupuis, L. L., ... & Portwine, C. (2013) [28]			management strategies and their effectiveness	MS SQL Server 2008 – Database; Internet Technology, Mobile Computing, Computer Graphics (Gamification)				2. pain drawing (location) 3. MCQs (duration of pain, causes of pain, pain management strategies used and their effectiveness.) 4. List of options to select from 5. free-text question as additional information	
Nes, A. A., Eide, H., Kristjánsdóttir, Ó. B., & van Dulmen, S. (2013) [42]	chronic widespread musculoskeletal pain	Age not specified, female, literacy level not mentioned	Pain Catastrophizing pain intensity and fatigue	PDA / Smartphone; Web based and flexible to use on PDA and smart phones; Internet Technology & Mobile Computing & Web Technology	active	3 times a day	multiple choice question	static & standard	
Garcia-Palacios, A., Herrero, R., Belmonte, M. A., Castilla, D., Guixeres, J., Molinari, G., ... & Botella, C. (2014) [43]	chronic pain in fibromyalgia	37-65 years, Female, low level of education and low familiarity with technology.	pain intensity fatigue intensity mood	Smartphone; windows mobile 6.1; Internet Technology & Mobile Computing	active	three times a day	1. numerical rating scale (pain and fatigue) 2. faced based pictorial rating scale (mood)	static & standard	
Pombo, N., Araújo, P., Viana, J., & da Costa, M. D. (2014) [21]	acute post-operative pain after ambulatory surgery	18–75 years, both male and female, participants had basic computer and mobile phone literacy	pain intensity	Smartphone; Android SQLite database WS (developed in Windows Communication Foundation, WCF); Internet Technology & Mobile Computing & Web Technology	active	5 times a day	Numeric rating scale	Dynamic & customized	
Jibb, L. A., Stevens, B. J., Nathan, P. C., Seto, E., Cafazzo, J. A., & Stinson, J. N. (2014) [29]	pediatric cancer pain	12-18 years, both male and female, 90% participants had own smartphones and comfortable in using this technology	pain intensity at the time of recording, pain intensity before 12 hours, pain interference with daily activities and sense not being able to control pain	Smartphone; Apple iOS; Internet Technology & Mobile Computing	active	not mentioned	1. visual analogue slider (dimensions of pain) 2. pain drawing (location) 3. MCQs (duration of pain, causes of pain, pain management strategies used and their effectiveness.)	static & standard	

								4. List of options to select from 5. free-text question as additional information
Blödt, S., Pach, D., Roll, S., & Witt, C. M. (2014) [39]	Chronic Low Back Pain Chronic Neck Pain	18 to 65 years, gender not specified, participants had smartphone literacy	pain intensity pain acceptance, stress, sick leaves, pain medication intake, adherence, suspected adverse reaction, and serious adverse events	Smartphone; iOS and Android both; Internet Technology & Mobile Computing	active	once a day	multiple choice question	static & standard
Maguire, R., Ream, E., Richardson, A., Connaghan, J., Johnston, B., Kotronoulas, G., ... & Webster, L. (2015) [30]	Lung Cancer Pain	>=18 years, both male and female, less familiarity with use of technology	pain, fatigue, nausea, depression, anxiety, drowsiness, shortness of breath, lack of appetite, sleep disorders, and impaired feeling of well-being	Smartphone; not mentioned; Internet Technology & Mobile Computing	active	one time a day	Multiple choice questions	static & standard
Jonassaint, C. R., Shah, N., Jonassaint, J., & De Castro, L. (2015) [57]	sickle cell	16–54 years, both male and female, technology literacy	clinical symptoms, pain intensity, location and perceived severity, and treatment strategies	smartphone – iPhone, iPod Touch, tablet – iPad; Apple IOS; Internet Technology & Mobile Computing	active	2 times a day or when required	VAS - horizontal multiple selection list	Static & partially customized (pharmacological intervention specific to patient's clinical pain regimen) customization on other app features as well
Huguet, A., McGrath, P. J., Wheaton, M., Mackinnon, S. P., Rozario, S., Tougas, M. E., ... & MacLean, C. (2015) [55]	headache	14-28 years, both male and female, literacy level not mentioned	It tracks temporal, sensory, and affective aspects of headaches, and headaches' impact on daily life, potential triggers, and coping behaviors.	smartphone – iPhone; Apple IOS; Internet Technology & Mobile Computing	active	once a day or as per required	VAS - horizontal drop down list check boxes, text input fields	Static & standard question (optional as well) customized response set
Nguyen, A. M., Humphrey, L., Kitchen, H., Rehman, T., & Norquist, J. M.	dysmenorrhea pelvic pain	14–50 years, female, all educational levels and age group	menstrual bleeding severity, pelvic pain/cramps severity, use of analgesics, and impact on work/school,	PDA; platform not mentioned; Internet Technology & Mobile Computing	active	Complete items each evening before bed (between 7 p.m. and	pain drawing (location) numerical rating scale (11 points) likert scale (yes/no)	static & standard

(2015) [56]			physical activities, social and leisure activities, and sleep.				midnight) so they could focus on the entire day and previous night.		
Bakshi, N., Stinson, J. N., Ross, D., Lukombo, I., Mittal, N., Joshi, S. V., ... & Krishnamurti, L. (2015) [37]	Vaso-occlusive pain - sickle cell disease	Adolescents and Young Adults, both male and female, literacy level not mentioned	pain intensity (current, worst, and average), unpleasantness, pain descriptors, precipitating factors, pain interference with daily life including sleep, school, mobility, fatigue and enjoying life, and pain relieving treatments and response to treatments	Smartphone, computer, or tablet; platform not mentioned; Internet Technology & Mobile Computing & Web Technology	active	twice daily	pain drawing (location) numerical rating scale Check boxes	Dynamic & standard	
Hochstenbach, L. M., Zwakhalen, S. M., Courtens, A. M., van Kleef, M., & de Witte, L. P. (2016) [32]	cancer pain	Age not specified, both male and female, literacy level not mentioned	Patients registered their pain, adverse effects, interference of pain with activity or sleep, and satisfaction with pain treatment by use of a pain diary twice-daily. Medication intake	iPad; Apple iOS; Internet Technology & Mobile Computing	active	twice daily	Numerical Rating Scale MCQs	static & standard	
Fortier, M. A., Chung, W. W., Martinez, A., Gago-Masague, S., & Sender, L. (2016) [31]	cancer pain	8-18 years, both male and female, literacy level not mentioned	frequency, severity, distress	tablet PC; Android; Internet Technology & Mobile Computing & Web Technology	active	twice a day for 10 days	Numerical Rating Scale Pain drawing / body map VAS - horizontal (Word graphic rating scale) Word List (to circle words)	static & standard	
Ingadottir, B., Blondal, K., Thue, D., Zoega, S., Thylen, I., & Jaarsma, T. (2017) [22]	post-operative pain	≥18 years, both male and female, technology literacy	pain intensity, pain medication intake	tablet PC; Android; Internet Technology, Mobile Computing, Computer Graphics (Gamification)	active	not mentioned	Numerical Rating Scale	static & standard	
Jibb, L. A., Cafazzo, J. A., Nathan, P. C., Seto, E., Stevens, B. J., Nguyen, C., & Stinson, J. N. (2017) [33]	cancer pain	12-18 years, both male and female, literacy level not mentioned	sensory, effective and evaluative nature of pain as well as questions related to pain management strategies and their effectiveness	smartphone – iPhone; Apple iOS; Internet Technology, Mobile Computing, Computer Graphics (Gamification)	active	2 times a day each morning and evening. If an adolescent experiences	1. visual analogue slider (dimensions of pain) 2. pain drawing (location) 3. MCQs (duration of pain, causes of pain,	static & standard	

pain anytime between these scheduled assessments, a truncated 8-item pain questionnaire can be completed to minimize the response burden for adolescents

pain management strategies used and their effectiveness.)

4. List of options to select from

5. free-text question as additional information

Table S2. Summary of Study Characteristics–Pain Management Mobile Applications aspects of usability and some additional data.

Author & Year	Is Usability Evaluation Done by Real Users or By Experts? (Duration and Number of Persons Involved)	Empirical Methods to Evaluate Usability	Which Usability Features Are More Targeted in the Studies?	Help Feature	Review Feature	System Design - User Centered?	Clinical Expertise Involved?
Serif, T., & Ghinea, G. (2005) [38]	3 real time users, 5 days - first iteration after modifications second iteration 50 patients, 5 days 4 clinicians, 7 days	questionnaire – patients; open ended questionnaire - clinicians	clarity of content, font size, color scheme, navigation	no	no	yes	yes
Stinson, J. N., Petroz, G. C., Tait, G., Feldman, B. M., Streiner, D., McGrath, P. J., & Stevens, B. J. (2006) [44]	2 cycles - 10 patients each,	think aloud open-ended interview questions	learnability, ease of use, ease to understand, completion time, satisfaction, error	no	"semi	yes	no
Kearney, N., Kidd, L., Miller, M., Sage, M., Khorrami, J., McGee, M., ... & Gray, P. (2006) [58]	18 patients, 9 health professionals	pre and post evaluation questionnaire, interview, software log of activity	Patients: Perceived ease of use, usefulness, Knowledge and confidence, Self-care behavior and symptom management, Communication and support	not mentioned	can undo a response before proceeding	yes	yes

			Health Professional: Understanding symptom experiences, Monitoring and managing symptoms, Communication and support, workload demand feedback between patients and project nurse					
Sorbi, M. J., Mak, S. B., Houtveen, J. H., Kleiboer, A. M., & van Doornen, L. J. (2007) [40]	usability testing with real time users 5 women, 8.5 days (2 phase testing) The first test run with three participants tested 4-5 diary prompts per day. The second run with another three participants (including one subject who participated in both runs) tested a reduced prompting scheme (2-3 prompts per day) and minor adaptations to the diary	Evaluative Questionnaire and Interview	User-friendliness of the PDA, Immediate compliance with online monitoring, Impact of ODA, ODA support of behavioral training key targets	no		but can not reverse back to review previous response"	no	No
Anatchkova, M. D., Saris-Baglama, R. N., Kosinski, M., & Bjorner, J. B. (2009) [23]	Half of the participants (n = 50) evaluated the dynamic form and the other half (n = 50) evaluated the static form. A 4 months feasibility study followed by questionnaire evaluation	questionnaire	helpfulness of the tool in understanding the impact of pain, relevance of the items, difficulty of completing the assessment, and willingness to complete the survey again	no		not mentioned	No Users were asked to evaluate the system for feedback and changes will be made in future research	no
McClellan, C. B., Schatz, J. C., Puffer, E., Sanchez, C. E., Stancil, M. T., & Roberts, C. W. (2009) [34]	19 participants, 8 weeks intervention patient and care taker (parents)	questionnaire	protocol attractiveness, consumer satisfaction: level of difficulty in using the protocol, perceptions of efficacy of the pain management strategies, satisfaction with the protocol, and whether the parent or	yes		no	no	no

			child would recommend the protocol to others				
Luckmann, R., & Vidal, A. (2010) [24]	usability testing with 4 users and 1 hour each on the basis of formal protocols and scenarios that were videotaped	reviewed the video tapes, took notes on user behaviors and dialogue that	comprehensiveness of the queries, response set and interface	no	no (as dynamic)	yes	no
Hachizuka, M., Yoshiuchi, K., Yamamoto, Y., Iwase, S., Nakagawa, K., Kawagoe, K., & Akabayashi, A. (2010) [26]	15 patients recorded pain details for 7 days	interview	user-friendliness of the device and simplicity of the content	no	yes	yes	no
Rosser, B. A., McCullagh, P., Davies, R., Mountain, G. A., McCracken, L., & Eccleston, C. (2011) [15]			Ease of use	no	yes	yes	yes
Jacob, E., Stinson, J., Duran, J., Gupta, A., Gerla, M., Lewis, M. A., & Zeltzer, L. (2012) [35]	1 patient - initial pre-test 3 patients - second pre-test 10 patients - pilot study 1, one hour session 21 patients - pilot study 2, one hour session	not mentioned	ease of use, accuracy, efficiency, responsiveness of the screens to touch, navigation, functionalities (submit, clear, cursor movement), visual appearance and layout, error prevention, clarification of the wording of questions, readability, user-interaction	no	no	yes	No it is based on the measures of pain and symptoms found from literature specifically for children suffering from sickle cell disease
Spyridonis, F., Grønli, T. M., Hansen, J., & Ghinea, G. (2012)	7 real users, usability test 15-18mins	questionnaire	ease of use, complexity, learnability, inconsistency, self-efficacy, clarity, error	no	no	no	yes

[46]			prevention, attractiveness.				
Baggott, C., Gibson, F., Coll, B., Kletter, R., Zeltzer, P., & Miaskowski, C. (2012) [27]	10 patients, 3 weeks trial	questionnaire, think-aloud and interview	usefulness	yes	no	no	yes
Stinson, J. N., Jibb, L. A., Nguyen, C., Nathan, P. C., Maloney, A. M., Dupuis, L. L., ... & Portwine, C. (2013) [28]	15, Phase 1a: Low-Fidelity usability testing 18, Phase 1b: High-Fidelity usability and Content Validity Testing 14, Clinical feasibility testing	qualitative semi-structured, audio-taped interviews questionnaire	understandability, esthetics, ease of use, content validity, satisfaction	no	no	yes	yes
Nes, A. A., Eide, H., Kristjánsdóttir, Ó. B., & van Dulmen, S. (2013) [42]	real time users, 4 weeks	questionnaire, interview	ease of use	no	no	no	no
Garcia-Palacios, A., Herrero, R., Belmonte, M. A., Castilla, D., Guixeres, J., Molinari, G., ... & Botella, C. (2014) [43]	real time users, 47, 1 week	questionnaire (acceptability, preferences, technological profile)	accuracy, completeness ease of use, usefulness, efficiency	yes audio instructions	no	no	no
Pombo, N., Araújo, P., Viana, J., & da Costa, M. D. (2014) [21]	real time users, 32, 5 days	questionnaire	acceptability, patient satisfaction, patient compliance stability, scalability, reliability of system	no	no	no	no
Jibb, L. A., Stevens, B. J., Nathan, P. C., Seto, E., Cafazzo, J. A., & Stinson, J. N.	healthcare professional, adolescents	audio-recorded interviews	usefulness, likability and effectiveness	no	no	yes phased and user-centered approach	yes

(2014) [29]								
Blödt, S., Pach, D., Roll, S., & Witt, C. M. (2014) [39]			ease of use	yes	no	yes stakeholders were involved in requirement gathering	yes App concept was approved by data protection officer	
Maguire, R., Ream, E., Richardson, A., Connaghan, J., Johnston, B., Kotronoulas, G., ... & Webster, L. (2015) [30]	16 patients, 13 healthcare professionals, 7 days during treatment and 1 month post treatment	interview, questionnaire	ease of use, self-efficacy	no	no	no	yes	
Jonassaint, C. R., Shah, N., Jonassaint, J., & De Castro, L. (2015) [57]	15 patients used app for 28 days	email, interview	usefulness, ease of use	no	no	no	yes	
Huguet, A., McGrath, P. J., Wheaton, M., Mackinnon, S. P., Rozario, S., Tougas, M. E., ... & MacLean, C. (2015) [55]	14 days 11-19 unique participants three cycles of usability testing	questionnaire, interview	Efficiency, Acceptability, Learnability	yes tutorials	no	iterative participatory design	yes	
Nguyen, A. M., Humphrey, L., Kitchen, H., Rehman, T., & Norquist, J. M. (2015) [56]	24 dysmenorrhea patients pilot-tested the eDiary for 1–5 weeks	think-aloud, interviews	content validity, comprehensive and easy to complete/understand	yes	no	yes	yes	

Bakshi, N., Stinson, J. N., Ross, D., Lukombo, I., Mittal, N., Joshi, S. V., ... & Krishnamurti, L. (2015) [37]	<p>Identification of Items: Two iterative cycles of expert review were conducted with 15 experts in the first cycle and 12 experts in the second cycle.</p> <p>Testing: 7 patients</p>	observation and field notes, semi-structured interview	<p>language, content, and relevance, understanding, paraphrasing, comprehension (meaning and understanding of the question), memory retrieval (ability to accurately recall the answer), relevance of the question, and Specific probes related to SCD (specificity of the item to SCD).</p>	yes	yes	iterative participatory design	yes
Hochstenbach, L. M., Zwakhalen, S. M., Courtens, A. M., van Kleef, M., & de Witte, L. P. (2016) [32]	real time users as well as experts 30-60mins interview with patients 90mins focus group discussion with nurses	Questionnaire Semi-structure interview Focus Group discussion	ease of use, understandability, navigation and interaction	not mentioned	yes	yes	yes
Fortier, M. A., Chung, W. W., Martinez, A., Gago-Masague, S., & Sender, L. (2016) [31]	real time users	Questionnaire	usefulness, satisfaction, attractiveness	tutorials only for behavioral skill training A three-dimensional(3-D)avatar that guides the child throughout the program	yes	iterative participatory design	yes
Ingadottir, B., Blondal, K., Thue, D., Zoega, S., Thylen, I., & Jaarsma, T. (2017) [22]	real users (n = 20)	Questionnaires, direct observation by a nonparticipant observer, and short semi structured interviews.	Ease of Use and Usefulness	no	not mentioned	iterative participatory design	yes

Jibb, L. A., Cafazzo, J. A., Nathan, P. C., Seto, E., Stevens, B. J., Nguyen, C., & Stinson, J. N. (2017) [33]	real time users (n = 16) 3 testing cycles	Observation, Think-aloud, Semi structured interview	ease of use, understandability, efficiency and acceptability	no	no	user-centered and iterative design approach	yes
----------------------------------------------------------------------------------------------------------------	----------------------------------------------	--------------------------------------------------------------	-----------------------------------------------------------------------	----	----	------------------------------------------------------	-----