Developing digital health interventions for falls prevention

An innovative user-centered design approach

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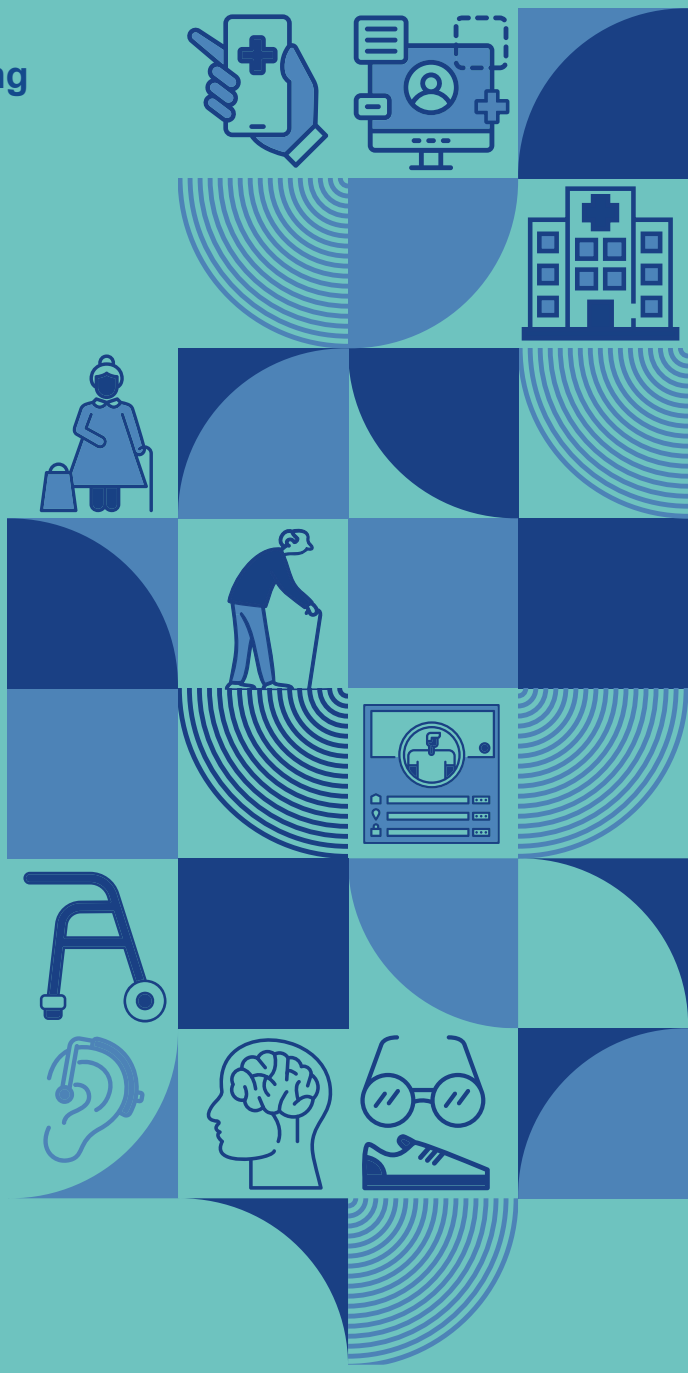
Addendum



References

Abernethy, A., Adams, L., Barrett, M., Bechtel, C., Brennan, P., Butte, A., ... & Valdes, K. (2022). The promise of digital health: then, now, and the future. *NAM perspectives*, *6*(22). https://doi.org/10.31478/202206e

Abras, C., Maloney-Krichmar, & Preece. (2005). User-centered design. In *Encyclopedia of Human-Computer Interaction* (Brainbridge, W., Ed., pp. 445–456). Sage Publications.

Ackerman, I. N., Soh, S., & Barker, A. L. (2020). Physical therapists' falls prevention knowledge, beliefs, and practices in osteoarthritis care: A national cross-sectional study. *Arthritis Care & Research*, *72*(8), 1087–1095. https://doi.org/10.1002/acr.23996

Adlin, T., & Pruitt, J. (2010). *The essential persona lifecycle: Your guide to building and using personas*. Morgan Kaufmann.

Ajzen, I. (2006). *Constructing a theory of planned behavior questionnaire*.

Akhloufi, H., Verhaegh, S. J. C., Jaspers, M. W. M., Melles, D. C., Van Der Sijs, H., & Verbon, A. (2019). A usability study to improve a clinical decision support system for the prescription of antibiotic drugs. *PLOS ONE*, *14*(9), e0223073. https://doi.org/10.1371/journal.pone.0223073

Albert, W., & Tullis, T. S. (2023). *Measuring the user experience: Collecting, analyzing, and presenting UX metrics.* Morgan Kaufmann. https://doi.org/10.1016/B978-0-12-818080-8.00016-9

Alroobaea, R., & Mayhew, P. J. (2014). How many participants are really enough for usability studies? *2014 Science and Information Conference*, 48–56. https://doi.org/10.1109/SAI.2014.6918171

Alruwaili, M. M., Shaban, M., & Elsayed Ramadan, O. M. (2023). Digital health interventions for promoting healthy aging: A systematic review of adoption patterns, efficacy, and user experience. *Sustainability*, *15*(23), 16503. https://doi.org/10.3390/su152316503

Alsos, O. A., & Svanæs, D. (2011). Designing for the secondary user experience. In *Human-Computer Interaction – INTERACT 2011: 13th IFIP TC 13 International Conference, Lisbon, Portugal, September 5-9, 2011, Proceedings, Part IV* (Vol. 6949). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-23768-3

Alvarado, N., McVey, L., Wright, J., Healey, F., Dowding, D., Cheong, V. L., Gardner, P., Hardiker, N., Lynch, A., Zaman, H., Smith, H., & Randell, R. (2023). Exploring variation in implementation of multifactorial falls risk assessment and tailored interventions: A realist review. *BMC Geriatrics*, *23*(1), 381. https://doi.org/10.1186/s12877-023-04045-3

Ambrose, A. F., Paul, G., & Hausdorff, J. M. (2013). Risk factors for falls among older adults: A review of the literature. *Maturitas*, *75*(1), 51–61. https://doi.org/10.1016/j.maturitas.2013.02.009

Andre, T. S., Rex Hartson, H., Belz, S. M., & Mccreary, F. A. (2001). The user action framework: A reliable foundation for usability engineering support tools. *International Journal of Human-Computer Studies*, *54*(1), 107–136. https://doi.org/10.1006/ijhc.2000.0441

Angell, S. K., Keitsch, M., & Sigurjónsson, J. (2016). The significance of the secondary user experience when designing for medical diagnostics. In *Proceedings of NordDesign 2016: August 10-12, 2016, Trondheim, Norway*. NordDesign, Bristol, United Kingdom. The Design Society.

Badawy, M. A. E. M. D., Naing, L., Johar, S., Ong, S., Rahman, H. A., Tengah, D. S. N. A. P., Chong, C. L., & Tuah, N. A. A. (2022). Evaluation of cardiovascular diseases risk calculators for CVDs prevention and management: Scoping review. *BMC Public Health*, *22*(1), 1742. https://doi.org/10.1186/s12889-022-13944-w

Barmentloo, L. M., Dontje, M. L., Koopman, M. Y., Olij, B. F., Oudshoorn, C., Mackenbach, J. P., Polinder, S., & Erasmus, V. (2020). Barriers and facilitators for screening older adults on fall risk in a hospital setting: Perspectives from patients and healthcare professionals. *International Journal of Environmental Research and Public Health*, *17*(5), 1461. https://doi.org/10.3390/ijerph17051461

Bartholomew, L. K., Parcel, G. S., Kok, G., Gottlieb, N. H., & Fernández, M. E. (2011). *Planning health promotion programs: An intervention mapping approach* (3rd ed.). Jossey-Bass.

Bell, H. T., Steinsbekk, A., & Granas, A. G. (2015). Factors influencing prescribing of fall-risk-increasing drugs to the elderly: A qualitative study. *Scandinavian Journal of Primary Health Care*, *33*(2), 107–114. https://doi.org/10.3109/02813432.2015.1041829

Benz, C., Scott-Jeffs, W., Revitt, J., Brabon, C., Fermanis, C., Hawkes, M., Keane, C., Dyke, R., Cooper, S., Locantro, M., Welsh, M., Norman, R., Hendrie, D., & Robinson, S. (2024). Co-designing a telepractice journey map with disability customers and clinicians: Partnering with users to understand challenges from their perspective. *Health Expectations*, *27*(1), e13919. https://doi.org/10.1111/hex.13919

Bierbooms, J. J. P. A., Sluis-Thiescheffer, W. R. J. W., Feijt, M. A., IJsselsteijn, W. A., & Bongers, I. M. B. (2021). Design of a game-based training environment to enhance health care professionals' e–mental health skills: Protocol for a user requirements analysis. *JMIR Research Protocols*, *10*(2), e18815. https://doi.org/10.2196/18815

Bloomfield, H. E., Greer, N., Linsky, A. M., Bolduc, J., Naidl, T., Vardeny, O., MacDonald, R., McKenzie, L., & Wilt, T. J. (2020). Deprescribing for community-dwelling older adults: A systematic review and meta-analysis. *Journal of General Internal Medicine*, *35*(11), 3323–3332. https://doi.org/10.1007/s11606-020-06089-2

Boyé, N. D. A., van der Velde, N., de Vries, O. J., van Lieshout, E. M. M., Hartholt, K. A., Mattace-Raso, F. U. S., Lips, P., Patka, P., van Beeck, E. F., van der Cammen, T. J. M., & IMPROveFALL trial collaborators. (2017). Effectiveness of medication withdrawal in older fallers: Results from the improving medication prescribing to reduce risk of falls (IMPROveFALL) trial. *Age and Ageing*, *46*(1), 142–146. https://doi.org/10.1093/ageing/afw161

Brandes, K., Linn, A. J., Smit, E. G., & Van Weert, J. C. M. (2015). Patients' reports of barriers to expressing concerns during cancer consultations. *Patient Education and Counseling*, *98*(3), 317–322. https://doi.org/10.1016/j.pec.2014.11.021

Brandes, K., Linn, A. J., Smit, E. G., & Van Weert, J. C. M. (2016). Unraveling the determinants of cancer patients' intention to express concerns. *Journal of Health Communication*, *21*(3), 327–336. https://doi.org/10.1080/10810730.2015.1080325

Brooks, C., Ballinger, C., Nutbeam, D., & Adams, J. (2017). The importance of building trust and tailoring interactions when meeting older adults' health literacy needs. *Disability and Rehabilitation*, *39*(23), 2428–2435. https://doi.org/10.1080/09638288.2016.1231849

Brunner, J., Chuang, E., Goldzweig, C., Cain, C. L., Sugar, C., & Yano, E. M. (2017). User-centered design to improve clinical decision support in primary care. *International Journal of Medical Informatics*, *104*, 56–64. https://doi.org/10.1016/j.ijmedinf.2017.05.004 data-research/index.html

Casey, C. M., Parker, E. M., Winkler, G., Liu, X., Lambert, G. H., & Eckstrom, E. (2016). Lessons learned from implementing CDC's STEADI falls prevention algorithm in primary care. *The Gerontologist*, gnw074. https://doi.org/10.1093/geront/gnw074

Centers for Disease Control and Prevention (CDC). (2024). *Older Adult Falls Data*. Older Adult Fall Prevention. https://www.cdc.gov/falls/data-research/index.html

Chandran, S., Al-Sa'di, A., & Ahmad, E. (2020). Exploring user centered design in healthcare: A literature review. *2020 4th International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT)*, 1–8. https://doi.org/10.1109/ISMSIT50672.2020.9255313

Chang, J. T., Morton, S. C., Rubenstein, L. Z., Mojica, W. A., Maglione, M., Suttorp, M. J., Roth, E. A., & Shekelle, P. G. (2004). Interventions for the prevention of falls in older adults: Systematic review and meta-analysis of randomised clinical trials. *BMJ*, *328*(7441), 680. https://doi.org/10.1136/bmj.328.7441.680

Chilana, P. K., Ko, A. J., & Wobbrock, J. (2015). From user-centered to adoption-centered design: A case study of a HCI research innovation becoming a product. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, 1749–1758. https://doi.org/10.1145/2702123.2702412

Chong, T. W. H., Rego, T., Lai, R., Westphal, A., Pond, C. D., Curran, E., Kootar, S., Peters, R., Anstey, K. J., & Lautenschlager, N. T. (2023). Preferences and perspectives of Australian general practitioners towards a new "four-in-one" risk assessment tool for preventative health: The LEAD! GP Project. *Journal of Alzheimer's Disease*, *94*(2), 801–814. https://doi.org/10.3233/JAD-230287

Clyne, B., Bradley, M. C., Hughes, C., Fahey, T., & Lapane, K. L. (2012). Electronic prescribing and other forms of technology to reduce inappropriate medication use and polypharmacy in older people: A review of current evidence. *Clinics in Geriatric Medicine*, *28*(2), 301–322. https://doi.org/10.1016/j.cger.2012.01.009

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., & Petticrew, M. (2013). Developing and evaluating complex interventions: The new medical research council guidance. *International Journal of Nursing Studies*, *50*(5), 587–592. https://doi.org/10.1016/j.ijnurstu.2012.09.010

Curran, G. M., Bauer, M., Mittman, B., Pyne, J. M., & Stetler, C. (2013). Effectiveness-implementation hybrid design. *Medical Care, 50*(3), 217–226. https://doi.org/10.1097/MLR.0b013e3182408812

Czuber, N. K., Garabedian, P. M., Rice, H., Tejeda, C. J., Dykes, P. C., & Latham, N. K. (2024). Human-centered design and development of a fall prevention exercise app for older adults in primary care settings. *Applied Clinical Informatics*, *15*(3), 544–555. https://doi.org/10.1055/a-2267-1727

Dalton, K., O'Brien, G., O'Mahony, D., & Byrne, S. (2018). Computerised interventions designed to reduce potentially inappropriate prescribing in hospitalised older adults: A systematic review and meta-analysis. *Age and Ageing*, *47*(5), 670–678. https://doi.org/10.1093/ageing/afy086

Damoiseaux-Volman, B. A., Van Der Velde, N., Ruige, S. G., Romijn, J. A., Abu-Hanna, A., & Medlock, S. (2021). Effect of interventions with a clinical decision support system for hospitalized older patients: Systematic review mapping implementation and design factors. *JMIR Medical Informatics*, *9*(7), e28023. https://doi.org/10.2196/28023

Davies, E. L., Bulto, L. N., Walsh, A., Pollock, D., Langton, V. M., Laing, R. E., Graham, A., Arnold-Chamney, M., & Kelly, J. (2023). Reporting and conducting patient journey mapping research in healthcare: A scoping review. *Journal of Advanced Nursing*, *79*(1), 83–100. https://doi.org/10.1111/jan.15479

De Vries, M., Seppala, L. J., Daams, J. G., van de Glind, E. M. M., Masud, T., van der Velde, N., & EUGMS Task and Finish Group on Fall-Risk-Increasing Drugs. (2018). Fall-risk-increasing drugs: A systematic review and meta-analysis: I. Cardiovascular drugs. *Journal of the American Medical Directors Association*, *19*(4), 371. e1-371.e9. https://doi.org/10.1016/j.jamda.2017.12.013

De Wildt, K. K., van de Loo, B., Linn, A. J., Medlock, S. K., Groos, S. S., Ploegmakers, K. J., Seppala, L. J., Bosmans, J. E., Abu-Hanna, A., van Weert, J. C. M., van Schoor, N. M., van der Velde, N., & AD*F*ICE_IT study team. (2023). Effects of a clinical decision support system and patient portal for preventing medication-related falls in older fallers: Protocol of a cluster randomized controlled trial with embedded process and economic evaluations (AD*F*ICE_IT). *PloS One*, *18*(9), e0289385. https://doi.org/10.1371/journal.pone.0289385

Denkinger, M. D., Franke, S., Rapp, K., Weinmayr, G., Duran-Tauleria, E., Nikolaus, T., Peter, R., & ActiFE Ulm Study Group. (2010). Accelerometer-based physical activity in a large observational cohort—Study protocol and design of the activity and function of the elderly in Ulm (ActiFE Ulm) study. *BMC Geriatrics*, *10*, 50. https://doi.org/10.1186/1471-2318-10-50

Dhippayom, T., Chaiyakunapruk, N., & Krass, I. (2014). How diabetes risk assessment tools are implemented in practice: A systematic review. *Diabetes Research and Clinical Practice*, *104*(3), 329–342. https://doi.org/10.1016/j.diabres.2014.01.008

Dopp, A. R., Parisi, K. E., Munson, S. A., & Lyon, A. R. (2019). A glossary of user-centered design strategies for implementation experts. *Translational Behavioral Medicine*, *9*(6), 1057–1064. https://doi.org/10.1093/tbm/iby119

Dos Santos, R. B., Lago, G. N., Jencius, M. C., Barbosa, B. A., Lima, C. A., Paschoal, S. M., Hill, K. D., Leme, L. E. G., & Perracini, M. R. (2021). Older adults' views on barriers and facilitators to participate in a multifactorial falls prevention program: Results from Prevquedas Brasil. *Archives of Gerontology and Geriatrics*, *92*, 104287. https://doi.org/10.1016/j.archger.2020.104287

Doyle, C., Lennox, L., & Bell, D. (2013). A systematic review of evidence on the links between patient experience and clinical safety and effectiveness. *BMJ Open*, *3*(1), e001570. https://doi.org/10.1136/bmjopen-2012-001570

Drickamer, M. A., Levy, B., Irwin, K. S., & Rohrbaugh, R. M. (2006). Perceived needs for geriatric education by medical students, internal medicine residents and faculty. *Journal of General Internal Medicine*, *21*(12), 1230–1234. https://doi.org/10.1111/j.1525-1497.2006.00585.x

Dumas, J. S., Redish, J. C., & Redish, J. (1994). *A practical guide to usability testing*. Greenwood Publishing Group Inc..

Ericsson, K., & Simon, H. (1984). *Protocol Analysis: Verbal Reports as Data*. MIT Press.

Express. (2017). *Fast, unopinionated, minimalist web framework for Node. js.* http://expressjs.com/

Federatie Medisch Specialisten. (n.d.). *Preventie van valincidenten bij ouderen*. https://richtlijnendatabase.nl/richtlijn/preventie_van_valincidenten_bij_ouderen/valrisicobeoordeling_thuiswonende_ouderen.html

Ferrucci, F., Jorio, M., Marci, S., Bezenchek, A., Diella, G., Nulli, C., Miranda, F., & Castelli-Gattinara, G. (2021). A web-based application for complex health care populations: User-centered design approach. *JMIR Human Factors*, *8*(1), e18587. https://doi.org/10.2196/18587

Fishbein, M., & Ajzen, I. (2011). *Predicting and changing behavior: The reasoned action approach.* Psychology Press. https://doi.org/10.4324/9780203838020

Flood, M., Ennis, M., Ludlow, A., Sweeney, F. F., Holton, A., Morgan, S., Clarke, C., Carroll, P., Mellon, L., Boland, F., Mohamed, S., De Brún, A., Hanratty, M., & Moriarty, F. (2021). Research methods from human-centered design: Potential applications in pharmacy and health services research. *Research in Social and Administrative Pharmacy*, *17*(12), 2036–2043. https://doi.org/10.1016/j.sapharm.2021.06.015

Francis, J., Eccles, M. P., Johnston, M., Walker, A. E., Grimshaw, J. M., Foy, R., Kaner, E. F. S., Smith, L., & Bonetti, D. (2004). *Constructing questionnaires based on the theory of planned behavior: A manual for health services researchers*. Newcastle upon Tyne, UK: Centre for Health Services Research, University of Newcastle upon Tyne.

Gade, G. V., Jørgensen, M. G., Ryg, J., Riis, J., Thomsen, K., Masud, T., & Andersen, S. (2021). Predicting falls in community-dwelling older adults: A systematic review of prognostic models. *BMJ Open*, *11*(5), e044170. https://doi.org/10.1136/bmjopen-2020-044170

Gagnon, M.-P., Desmartis, M., Labrecque, M., Car, J., Pagliari, C., Pluye, P., Frémont, P., Gagnon, J., Tremblay, N., & Légaré, F. (2012). Systematic review of factors influencing the adoption of information and communication technologies by healthcare professionals. *Journal of Medical Systems*, *36*(1), 241–277. https://doi.org/10.1007/s10916-010-9473-4

Garavand, A., Mohseni, M., Asadi, H., Etemadi, M., Moradi-Joo, M., & Moosavi, A. (2016). Factors influencing the adoption of health information technologies: A systematic review. *Electronic Physician*, *8*(8), 2713–2718. https://doi.org/10.19082/2713

Garrett, J. J. (2003). *The elements of user experience: User-centered design for the web* (1st ed). New Riders.

Gemmeke, M., Taxis, K., Bouvy, M. L., & Koster, E. S. (2022). Perspectives of primary care providers on multidisciplinary collaboration to prevent medication-related falls. *Exploratory Research in Clinical and Social Pharmacy*, *6*, 100149. https://doi.org/10.1016/j.rcsop.2022.100149

Gentili, A., Failla, G., Melnyk, A., Puleo, V., Tanna, G. L. D., Ricciardi, W., & Cascini, F. (2022). The cost-effectiveness of digital health interventions: A systematic review of the literature. *Frontiers in Public Health*, *10*, 787135. https://doi.org/10.3389/fpubh.2022.787135

Geriatrics Interdisciplinary Advisory Group. (2006). Interdisciplinary care for older adults with complex needs: American geriatrics society position statement: SPECIAL ARTICLE. *Journal of the American Geriatrics Society*, *54*(5), 849–852. https://doi.org/10.1111/j.1532-5415.2006.00707.x

Ghazali, M., Mat Ariffin, N. A., & Omar, R. (2014). User centered design practices in healthcare: A systematic review. *2014 3rd International Conference on User Science and Engineering (i-USEr)*, 91–96. https://doi.org/10.1109/IUSER.2014.7002683

Gillespie, L. D., Gillespie, W. J., Robertson, M. C., Lamb, S. E., Cumming, R. G., & Rowe, B. H. (2003). Interventions for preventing falls in elderly people. In The Cochrane Collaboration (Ed.), *The Cochrane Database of Systematic Reviews* (p. CD000340). John Wiley & Sons, Ltd. https://doi.org/10.1002/14651858.CD000340

Gillespie, L. D., Robertson, M. C., Gillespie, W. J., Sherrington, C., Gates, S., Clemson, L., & Lamb, S. E. (2012). Interventions for preventing falls in older people living in the community. *Cochrane Database of Systematic Reviews*, *2021*(6). https://doi.org/10.1002/14651858.CD007146.pub3

Giovannini, S., Brau, F., Galluzzo, V., Santagada, D. A., Loreti, C., Biscotti, L., Laudisio, A., Zuccalà, G., & Bernabei, R. (2022). Falls among older adults: Screening, identification, rehabilitation, and management. *Applied Sciences*, *12*(15), 7934. https://doi.org/10.3390/app12157934

Girwar, S. M., Jabroer, R., Fiocco, M., Sutch, S. P., Numans, M. E., & Bruijnzeels, M. A. (2021). A systematic review of risk stratification tools internationally used in primary care settings. *Health Science Reports*, *4*(3), e329. https://doi.org/10.1002/hsr2.329

Goodman, E., & Kuniavsky, M. (2012). *Observing the user experience: A practitioner's guide to user research*. Elsevier Science.

Göttgens, I., & Oertelt-Prigione, S. (2021). The application of human-centered design approaches in health research and innovation: A narrative review of current practices. *JMIR mHealth and uHealth*, *9*(12), e28102. https://doi.org/10.2196/28102

Goud, R., van Engen-Verheul, M., de Keizer, N. F., Bal, R., Hasman, A., Hellemans, I. M., & Peek, N. (2010). The effect of computerized decision support on barriers to guideline implementation: A qualitative study in outpatient cardiac rehabilitation. *International Journal of Medical Informatics*, *79*(6), 430–437. https://doi.org/10.1016/j.ijmedinf.2010.03.001

Graham, A. K., Munson, S. A., Reddy, M., Neubert, S. W., Green, E. A., Chang, A., Spring, B., Mohr, D. C., & Wildes, J. E. (2021). Integrating user-centered design and behavioral science to design a mobile intervention for obesity and binge eating: Mixed methods analysis. *JMIR Formative Research*, *5*(5), e23809. https://doi.org/10.2196/23809

Grant, A., Mackenzie, L., & Clemson, L. (2015). How do general practitioners engage with allied health practitioners to prevent falls in older people? An exploratory qualitative study. *Australasian Journal on Ageing*, *34*(3), 149–154. https://doi.org/10.1111/ajag.12157

Groos, S. S., De Wildt, K. K., Van De Loo, B., Linn, A. J., Medlock, S., Shaw, K. M., Herman, E. K., Seppala, L. J., Ploegmakers, K. J., Van Schoor, N. M., Van Weert, J. C. M., & Van Der Velde, N. (2024). Development of the AD*F*ICE_IT clinical decision support system to assist deprescribing of fall-risk increasing drugs: A user-centered design approach. *PLOS ONE*, *19*(9), e0297703. https://doi.org/10.1371/journal.pone.0297703

Groos, S. S., Linn, A. J., Kuiper, J. I., Van Schoor, N. M., Van Der Velde, N., & Van Weert, J. C. M. (2024). Combining user-centered design and behavioral theory to enhance health technologies: A personas-based approach for a primary-care based multifactorial falls risk assessment tool. *International Journal of Medical Informatics*, *186*, 105420. https://doi.org/10.1016/j.ijmedinf.2024.105420

Groos, S. S., Tan, S. M., Linn, A. J., Kuiper, J. I., Van Schoor, N. M., Van Weert, J. C. M., & Van Der Velde, N. (2025). Multidisciplinary care pathways for falls prevention in older adults: Visualizing the needs of primary care-based health care professionals. *European Geriatric Medicine*. https://doi.org/10.1007/s41999-024-01142-3

Guay, F., Vallerand, R. J., & Blanchard, C. (2000). On the assessment of situational intrinsic and extrinsic motivation: The situational motivation scale (SIMS). *Motivation and Emotion*, *24*(3), 175–213. https://doi.org/10.1023/A:1005614228250

Gupta, A., Maslen, C., Vindlacheruvu, M., Abel, R. L., Bhattacharya, P., Bromiley, P. A., Clark, E. M., Compston, J. E., Crabtree, N., Gregory, J. S., Kariki, E. P., Harvey, N. C., McCloskey, E., Ward, K. A., & Poole, K. E. S. (2022). Digital health interventions for osteoporosis and post-fragility fracture care. *Therapeutic Advances in Musculoskeletal Disease*, *14*, 1759720X221083523. https://doi.org/10.1177/1759720X221083523

Haagsma, J. A., Olij, B. F., Majdan, M., van Beeck, E. F., Vos, T., Castle, C. D., Dingels, Z. V., Fox, J. T., Hamilton, E. B., Liu, Z., Roberts, N. L. S., Sylte, D. O., Aremu, O., Bärnighausen, T. W., Borzì, A. M., Briggs, A. M., Carrero, J. J., Cooper, C., El-Khatib, Z., … Polinder, S. (2020). Falls in older aged adults in 22 European countries: Incidence, mortality and burden of disease from 1990 to 2017. *Injury Prevention: Journal of the International Society for Child and Adolescent Injury Prevention*, *26*(Supp 1), i67–i74. https://doi.org/10.1136/injuryprev-2019-043347

Harte, R., Quinlan, L. R., Glynn, L., Rodríguez-Molinero, A., Baker, P. M., Scharf, T., & ÓLaighin, G. (2017). Human-centered design study: Enhancing the usability of a mobile phone app in an integrated falls risk detection system for use by older adult users. *JMIR mHealth and uHealth*, *5*(5), e71. https://doi.org/10.2196/mhealth.7046

Hartholt, K. A., van Beeck, E. F., Polinder, S., van der Velde, N., van Lieshout, E. M. M., Panneman, M. J. M., van der Cammen, T. J. M., & Patka, P. (2011). Societal consequences of falls in the older population: Injuries, healthcare costs, and long-term reduced quality of life. *The Journal of Trauma*, *71*(3), 748–753. https://doi.org/10.1097/TA.0b013e3181f6f5e5

Heinrich, S., Rapp, K., Rissmann, U., Becker, C., & König, H.-H. (2010). Cost of falls in old age: A systematic review. *Osteoporosis International*, *21*(6), 891–902. https://doi.org/10.1007/s00198-009-1100-1

Hoffmann, T. C., & Del Mar, C. (2017). Clinicians' expectations of the benefits and harms of treatments, screening, and tests: A systematic review. *JAMA Internal Medicine*, *177*(3), 407–419. https://doi.org/10.1001/jamainternmed.2016.8254

Holden, R. J., Kulanthaivel, A., Purkayastha, S., Goggins, K. M., & Kripalani, S. (2017). Know thy eHealth user: Development of biopsychosocial personas from a study of older adults with heart failure. *International Journal of Medical Informatics*, *108*, 158–167. https://doi.org/10.1016/j.ijmedinf.2017.10.006

Hoogendijk, E. O., Deeg, D. J. H., de Breij, S., Klokgieters, S. S., Kok, A. A. L., Stringa, N., Timmermans, E. J., van Schoor, N. M., van Zutphen, E. M., van der Horst, M., Poppelaars, J., Malhoe, P., & Huisman, M. (2020). The longitudinal aging study amsterdam: Cohort update 2019 and additional data collections. *European Journal of Epidemiology*, *35*(1), 61–74. https://doi.org/10.1007/s10654-019-00541-2

Hopewell, S., Adedire, O., Copsey, B. J., Boniface, G. J., Sherrington, C., Clemson, L., Close, J. C., & Lamb, S. E. (2018). Multifactorial and multiple component interventions for preventing falls in older people living in the community. *Cochrane Database of Systematic Reviews*, *2018*(7). https://doi.org/10.1002/14651858.CD012221.pub2

Hopewell, S., Copsey, B., Nicolson, P., Adedire, B., Boniface, G., & Lamb, S. (2020). Multifactorial interventions for preventing falls in older people living in the community: A systematic review and meta-analysis of 41 trials and almost 20 000 participants. *British Journal of Sports Medicine*, *54*(22), 1340–1350. https://doi.org/10.1136/bjsports-2019-100732

Hsieh, K., Fanning, J., Frechette, M., & Sosnoff, J. (2021). Usability of a fall risk mHealth app for people with multiple sclerosis: Mixed methods study. *JMIR Human Factors*, *8*(1), e25604. https://doi.org/10.2196/25604

International Organization for Standardization (ISO). (1998). *Ergonomic requirements for office work with visual display terminals (VDT)s—Part 14 Menu dialogues: ISO/IEC 9241-14*. https://www.iso.org/standard/35864.html

Jacob, C., Sanchez-Vazquez, A., & Ivory, C. (2020). Social, organizational, and technological factors impacting clinicians' adoption of mobile health tools: Systematic literature review. *JMIR mHealth and uHealth*, *8*(2), e15935. https://doi.org/10.2196/15935

James, S. L., Lucchesi, L. R., Bisignano, C., Castle, C. D., Dingels, Z. V., Fox, J. T., Hamilton, E. B., Henry, N. J., Krohn, K. J., Liu, Z., McCracken, D., Nixon, M. R., Roberts, N. L. S., Sylte, D. O., Adsuar, J. C., Arora, A., Briggs, A. M., Collado-Mateo, D., Cooper, C., … Murray, C. J. L. (2020). The global burden of falls: Global, regional and national estimates of morbidity and mortality from the global burden of disease study 2017. *Injury Prevention*, *26*(Suppl 2), i3–i11. https://doi.org/10.1136/injuryprev-2019-043286

Jansen, A., Van Mechelen, M., & Slegers, K. (2017). Personas and behavioral theories: A case study using self-determination theory to construct overweight personas. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, 2127–2136. https://doi.org/10.1145/3025453.3026003

Jehu, D. A., Davis, J. C., Falck, R. S., Bennett, K. J., Tai, D., Souza, M. F., Cavalcante, B. R., Zhao, M., & Liu-Ambrose, T. (2021). Risk factors for recurrent falls in older adults: A systematic review with meta-analysis. *Maturitas*, *144*, 23–28. https://doi.org/10.1016/j.maturitas.2020.10.021

Jest. (2017). *Delightful JavaScript Testing*. https://jestjs.io/

Joseph, Kushinruk, & Borycki. (2020). Patient journey mapping: Current practices, challenges and future opportunities in healthcare. *Knowledge Management & E-Learning: An International Journal*, 387–404. https://doi.org/10.34105/j.kmel.2020.12.021

Kennedy, G., & Gallego, B. (2019). Clinical prediction rules: A systematic review of healthcare provider opinions and preferences. *International Journal of Medical Informatics*, *123*, 1–10. https://doi.org/10.1016/j.ijmedinf.2018.12.003

Khajouei, R., Peute, L. W. P., Hasman, A., & Jaspers, M. W. M. (2011). Classification and prioritization of usability problems using an augmented classification scheme. *Journal of Biomedical Informatics*, *44*(6), 948–957. https://doi.org/10.1016/j.jbi.2011.07.002

Khong, P. C. B., Holroyd, E., & Wang, W. (2015). A citical review of the theoretical frameworks and the conceptual factors in the adoption of clinical decision support systems. *Computers, Informatics, Nursing: CIN*, *33*(12), 555–570. https://doi.org/10.1097/CIN.0000000000000196

Kilsdonk, E., Peute, L. W., & Jaspers, M. W. M. (2017). Factors influencing implementation success of guideline-based clinical decision support systems: A systematic review and gaps analysis. *International Journal of Medical Informatics*, *98*, 56–64. https://doi.org/10.1016/j.ijmedinf.2016.12.001

Kok, G., Gottlieb, N. H., Peters, G.-J. Y., Mullen, P. D., Parcel, G. S., Ruiter, R. A. C., Fernández, M. E., Markham, C., & Bartholomew, L. K. (2016). A taxonomy of behaviour change methods: An intervention mapping approach. *Health Psychology Review*, *10*(3), 297–312. https://doi.org/10.1080/17437199.2015.1077155

Korylchuk, N., Pelykh, V., I., Nemyrovych, Y., Didyk, N., & Martsyniak, S. (2024). Challenges and benefits of a multidisciplinary approach to treatment in clinical medicine. *Journal of Pioneering Medical Science*, *13*(3), 1–9. https://doi.org/10.61091/jpms202413301

Kujala, S. (2003). User involvement: A review of the benefits and challenges. *Behaviour & Information Technology*, *22*(1), 1–16. https://doi.org/10.1080/01449290301782

Laing, S. S., Silver, I. F., York, S., & Phelan, E. A. (2011). Fall prevention knowledge, attitude, and practices of community stakeholders and older adults. *Journal of Aging Research*, *2011*, 395357. https://doi.org/10.4061/2011/395357

Langley, J., Wolstenholme, D., & Cooke, J. (2018). 'Collective making' as knowledge mobilisation: The contribution of participatory design in the co-creation of knowledge in healthcare. *BMC Health Services Research*, *18*(1), 585. https://doi.org/10.1186/s12913-018-3397-y

Ledel Solem, I. K., Varsi, C., Eide, H., Kristjansdottir, O. B., Børøsund, E., Schreurs, K. M. G., Waxenberg, L. B., Weiss, K. E., Morrison, E. J., Haaland-Øverby, M., Bevan, K., Zangi, H. A., Stubhaug, A., & Solberg Nes, L. (2020). A user-centered approach to an evidence-based electronic health pain management intervention for people with chronic pain: Design and development of EPIO. *Journal of Medical Internet Research*, *22*(1), e15889. https://doi.org/10.2196/15889

Lee, J., Negm, A., Peters, R., Wong, E. K. C., & Holbrook, A. (2021). Deprescribing fall-risk increasing drugs (FRIDs) for the prevention of falls and fall-related complications: A systematic review and meta-analysis. *BMJ Open*, *11*(2), e035978. https://doi.org/10.1136/bmjopen-2019-035978

Lee, S. H., & Yu, S. (2020). Effectiveness of multifactorial interventions in preventing falls among older adults in the community: A systematic review and meta-analysis. *International Journal of Nursing Studies*, *106*, 103564. https://doi.org/10.1016/j.ijnurstu.2020.103564

Leichtling, G., Hildebran, C., Novak, K., Alley, L., Doyle, S., Reilly, C., & Weiner, S. G. (2020). Physician responses to enhanced prescription drug monitoring program profiles. *Pain Medicine*, *21*(2), e9–e21. https://doi.org/10.1093/pm/pny291

LeRouge, C., Ma, J., Sneha, S., & Tolle, K. (2013). User profiles and personas in the design and development of consumer health technologies. *International Journal of Medical Informatics*, *82*(11), e251–e268. https://doi.org/10.1016/j.ijmedinf.2011.03.006

Lewis, J. R. (1994). Sample sizes for usability studies: Additional considerations. *Human Factors*, *36*(2), 368–378. https://doi.org/10.1177/001872089403600215

Li, J., Talaei-Khoei, A., Seale, H., Ray, P., & MacIntyre, C. R. (2013). Health care provider adoption of eHealth: Systematic literature review. *Interactive Journal of Medical Research*, *2*(1), e7. https://doi.org/10.2196/ijmr.2468

Li, Y., Hou, L., Zhao, H., Xie, R., Yi, Y., & Ding, X. (2023). Risk factors for falls among community-dwelling older adults: A systematic review and meta-analysis. *Frontiers in Medicine*, *9*, 1019094. https://doi.org/10.3389/fmed.2022.1019094

Liddle, J., Lovarini, M., Clemson, L., Mackenzie, L., Tan, A., Pit, S. W., Poulos, R., Tiedemann, A., Sherrington, C., Roberts, C., & Willis, K. (2018). Making fall prevention routine in primary care practice: Perspectives of allied health professionals. *BMC Health Services Research*, *18*(1), 598. https://doi.org/10.1186/s12913-018-3414-1

Liu, Y., Hayes, D. N., Nobel, A., & Marron, J. S. (2008). Statistical significance of clustering for high-dimension, low–sample size data. *Journal of the American Statistical Association*, *103*(483), 1281–1293. https://doi.org/10.1198/016214508000000454

Mackenzie, L., Beavis, A.-M., Tan, A. C. W., & Clemson, L. (2020). Systematic review and meta-Analysis of intervention studies with general practitioner involvement focused on falls prevention for community-dwelling older people. *Journal of Aging and Health*, *32*(10), 1562–1578. https://doi.org/10.1177/0898264320945168

Mackenzie, L., Clemson, L., & Roberts, C. (2013). Occupational therapists partnering with general practitioners to prevent falls: Seizing opportunities in primary health care. *Australian Occupational Therapy Journal*, *60*(1), 66–70. https://doi.org/10.1111/1440-1630.12030

Mackenzie, L., & McIntyre, A. (2019). How do general practitioners (GPs) engage in falls prevention with older people? A pilot survey of GPs in NHS England suggests a gap in routine practice to address falls prevention. *Frontiers in Public Health*, *7*, 32. https://doi.org/10.3389/fpubh.2019.00032

Mao, J.-Y., Vredenburg, K., Smith, P. W., & Carey, T. (2005). The state of user-centered design practice. *Communications of the ACM*, *48*(3), 105–109. https://doi.org/10.1145/1047671.1047677

MariaDB Foundation. (2015). *MariaDB server: The open source relational database*. https://mariadb.org/.

Masud, T., & Morris, R. O. (2001). *Epidemiology of falls*. *30*(S4), 3–7. https://www.schulich.uwo.ca/geriatrics/docs/2-Falls---Masud_Epidemiology-of-Falls.pdf

Mathews, S. C., McShea, M. J., Hanley, C. L., Ravitz, A., Labrique, A. B., & Cohen, A. B. (2019). Digital health: A path to validation. *Npj Digital Medicine*, *2*(1), 38. https://doi.org/10.1038/s41746-019-0111-3

McCarthy, S., O'Raghallaigh, P., Woodworth, S., Lim, Y. L., Kenny, L. C., & Adam, F. (2016). An integrated patient journey mapping tool for embedding quality in healthcare service reform. *Journal of Decision Systems*, *25*(sup1), 354–368. https://doi.org/10.1080/12460125.2016.1187394

McConville, A., & Hooven, K. (2021). Factors influencing the implementation of falls prevention practice in primary care. *Journal of the American Association of Nurse Practitioners*, *33*(2), 108–116. https://doi.org/10.1097/JXX.0000000000000360

McKay, C., & Anderson, K. E. (2010). How to manage falls in community dwelling older adults: A review of the evidence. *Postgraduate Medical Journal*, *86*(1015), 299–306. https://doi.org/10.1136/pgmj.2009.093468

Medlock, S., Opondo, D., Eslami, S., Askari, M., Wierenga, P., de Rooij, S. E., & Abu-Hanna, A. (2011). LERM (Logical Elements Rule Method): A method for assessing and formalizing clinical rules for decision support. *International Journal of Medical Informatics*, *80*(4), 286–295. https://doi.org/10.1016/j.ijmedinf.2011.01.014

Meekes, W. M., Leemrijse, C. J., Korevaar, J. C., Stanmore, E. K., & Van De Goor, L. (Ien) A. (2022). Implementing falls prevention in primary care: Barriers and facilitators. *Clinical Interventions in Aging*, *Volume 17*, 885–902. https://doi.org/10.2147/CIA.S354911

Miaskiewicz, T., & Kozar, K. A. (2011). Personas and user-centered design: How can personas benefit product design processes? *Design Studies*, *32*(5), 417–430. https://doi.org/10.1016/j.destud.2011.03.003

Michalcova, J., Vasut, K., Airaksinen, M., & Bielakova, K. (2020). Inclusion of medication-related fall risk in fall risk assessment tool in geriatric care units. *BMC Geriatrics*, *20*(1), 454. https://doi.org/10.1186/s12877-020-01845-9

Michie, S. (2008). Designing and implementing behaviour change interventions to improve population health. *Journal of Health Services Research & Policy*, *13*(3_suppl), 64–69. https://doi.org/10.1258/jhsrp.2008.008014

Miller, K., Mosby, D., Capan, M., Kowalski, R., Ratwani, R., Noaiseh, Y., Kraft, R., Schwartz, S., Weintraub, W. S., & Arnold, R. (2018). Interface, information, interaction: A narrative review of design and functional requirements for clinical decision support. *Journal of the American Medical Informatics Association: JAMIA*, *25*(5), 585–592. https://doi.org/10.1093/jamia/ocx118

Montero-Odasso, M., Van Der Velde, N., Martin, F. C., Petrovic, M., Tan, M. P., Ryg, J., Aguilar-Navarro, S., Alexander, N. B., Becker, C., Blain, H., Bourke, R., Cameron, I. D., Camicioli, R., Clemson, L., Close, J., Delbaere, K., Duan, L., Duque, G., Dyer, S. M., … Rixt Zijlstra, G. A. (2022). World guidelines for falls prevention and management for older adults: A global initiative. *Age and Ageing*, *51*(9), afac205. https://doi.org/10.1093/ageing/afac205

Moons, K. G. M., Altman, D. G., Reitsma, J. B., Ioannidis, J. P. A., Macaskill, P., Steyerberg, E. W., Vickers, A. J., Ransohoff, D. F., & Collins, G. S. (2015). Transparent reporting of a multivariable prediction model for individual prognosis or diagnosis (TRIPOD): Explanation and elaboration. *Annals of Internal Medicine*, *162*(1), W1-73. https://doi.org/10.7326/M14-0698

Moxey, A., Robertson, J., Newby, D., Hains, I., Williamson, M., & Pearson, S.-A. (2010). Computerized clinical decision support for prescribing: Provision does not guarantee uptake. *Journal of the American Medical Informatics Association: JAMIA*, *17*(1), 25–33. https://doi.org/10.1197/jamia.M3170

Muusse, J. S. C., Zuidema, R., Van Scherpenseel, M. C., & Velde, S. J. T. (2023). Influencing factors of interprofessional collaboration in multifactorial fall prevention interventions: A qualitative systematic review. *BMC Primary Care*, *24*(1), 116. https://doi.org/10.1186/s12875-023-02066-w

Nielsen, J. (1993). *Usability engineering*. Kaufmann.

Nimmanterdwong, Z., Boonviriya, S., & Tangkijvanich, P. (2022). Human-centered design of mobile health apps for older adults: Systematic review and narrative synthesis. *JMIR mHealth and uHealth*, *10*(1), e29512. https://doi.org/10.2196/29512

Node.js Foundation. (2019). *Node.js*. https://nodejs.org/en/

Norman, D. A., & Draper, S. W. (1986). *User centered system design: New perspectives on human-computer interaction*. L. Erlbaum Associates Inc.

Olaronke, Soriyan, Gambo, & Olaleke. (2013). Interoperability in healthcare: Benefits, challenges and resolutions. *International Journal of Innovation and Applied Studies*, *3*(1), 262-270.

Parkinson, A., Jorm, L., Douglas, K. A., Gee, A., Sargent, G. M., Lujic, S., & McRae, I. S. (2015). Recruiting general practitioners for surveys: Reflections on the difficulties and some lessons learned. *Australian Journal of Primary Health*, *21*(2), 254. https://doi.org/10.1071/PY13129

Partala, T., & Saari, T. (2015). Understanding the most influential user experiences in successful and unsuccessful technology adoptions. *Computers in Human Behavior*, *53*, 381–395. https://doi.org/10.1016/j.chb.2015.07.012

Peel, C., Brown, C. J., Lane, A., Milliken, E., & Patel, K. (2008). A survey of fall prevention knowledge and practice patterns in home health physical therapists. *Journal of Geriatric Physical Therapy*, *31*(2), 64-70.

Peeters, G., Bennett, M., Donoghue, O. A., Kennelly, S., & Kenny, R. A. (2020). Understanding the aetiology of fear of falling from the perspective of a fear-avoidance model—A narrative review. *Clinical Psychology Review*, *79*, 101862. https://doi.org/10.1016/j.cpr.2020.101862

Perski, O., & Short, C. E. (2021). Acceptability of digital health interventions: Embracing the complexity. *Translational Behavioral Medicine*, *11*(7), 1473–1480. https://doi.org/10.1093/tbm/ibab048

Petersen, N., König, H.-H., & Hajek, A. (2020). The link between falls, social isolation and loneliness: A systematic review. *Archives of Gerontology and Geriatrics*, *88*, 104020. https://doi.org/10.1016/j.archger.2020.104020

Phelan, E. A., Mahoney, J. E., Voit, J. C., & Stevens, J. A. (2015). Assessment and management of fall risk in primary care settings. *Medical Clinics of North America*, *99*(2), 281–293. https://doi.org/10.1016/j.mcna.2014.11.004

Pit, S. W., Vo, T., & Pyakurel, S. (2014). The effectiveness of recruitment strategies on general practitioner's survey response rates – a systematic review. *BMC Medical Research Methodology*, *14*(1), 76. https://doi.org/10.1186/1471-2288-14-76

Ploegmakers, K. J., Medlock, S., Linn, A. J., Lin, Y., Seppälä, L. J., Petrovic, M., Topinkova, E., Ryg, J., Mora, M. A. C., Landi, F., Thaler, H., Szczerbińska, K., Hartikainen, S., Bahat, G., Ilhan, B., Morrissey, Y., Masud, T., van der Velde, N., van Weert, J. C. M., & European Geriatric Medicine Society (EuGMS) Task and Finish group on Fall-Risk Increasing Drugs (FRIDs). (2022). Barriers and facilitators in using a clinical decision support system for fall risk management for older people: A European survey. *European Geriatric Medicine*, *13*(2), 395–405. https://doi.org/10.1007/s41999-021-00599-w

Pollack, A. H., Simon, T. D., Snyder, J., & Pratt, W. (2019). Creating synthetic patient data to support the design and evaluation of novel health information technology. *Journal of Biomedical Informatics*, *95*, 103201. https://doi.org/10.1016/j.jbi.2019.103201

Prochaska, J. O., & Velicer, W. F. (1997). The transtheoretical model of health behavior Change. *American Journal of Health Promotion*, *12*(1), 38–48. https://doi.org/10.4278/0890-1171-12.1.38

Rahimi, B., Nadri, H., Lotfnezhad Afshar, H., & Timpka, T. (2018). A systematic review of the technology acceptance model in health informatics. *Applied Clinical Informatics*, *09*(03), 604–634. https://doi.org/10.1055/s-0038-1668091

Randell, R., Wright, J. M., Alvarado, N., Healey, F., Dowding, D., Smith, H., Hardiker, N., Gardner, P., Ward, S., Todd, C., Zaman, H., McVey, L., Davey, C. J., & Woodcock, D. (2021). What supports and constrains the implementation of multifactorial falls risk assessment and tailored multifactorial falls prevention interventions in acute hospitals? Protocol for a realist review. *BMJ Open*, *11*(9), e049765. https://doi.org/10.1136/bmjopen-2021-049765

Rice, H., Garabedian, P. M., Shear, K., Bjarnadottir, R. I., Burns, Z., Latham, N. K., Schentrup, D., Lucero, R. J., & Dykes, P. C. (2022). Clinical decision support for fall prevention: Defining end-user needs. *Applied Clinical Informatics*, *13*(03), 647–655. https://doi.org/10.1055/s-0042-1750360

Rogers, E. M. (1981). Diffusion of innovations: An overview. In J. G. Anderson & S. J. Jay (Eds.), *Use and Impact of Computers in Clinical Medicine* (pp. 113–131). Springer New York. https://doi.org/10.1007/978-1-4613-8674-2_9

Rubenstein, L. Z. (2006). Falls in older people: Epidemiology, risk factors and strategies for prevention. *Age and Ageing*, *35*(suppl_2), ii37–ii41. https://doi.org/10.1093/ageing/afl084

Ruggieri, M., Palmisano, B., Fratocchi, G., Santilli, V., Mollica, R., Berardi, A., & Galeoto, G. (2018). Validated fall risk assessment tools for use with older adults: A systematic review. *Physical & Occupational Therapy In Geriatrics*, *36*(4), 331–353. https://doi.org/10.1080/02703181.2018.1520381

Ruksakulpiwat, S., Benjasirisan, C., Ding, K., Phianhasin, L., Thorngthip, S., Ajibade, A., Thampakkul, J., Zhang, A., & Voss, J. G. (2023). Utilizing social determinants of health model to understand barriers to medication adherence in patients with ischemic stroke: A systematic review. *Patient Preference and Adherence*, *Volume 17*, 2161–2174. https://doi.org/10.2147/PPA.S420059

Salari, N., Darvishi, N., Ahmadipanah, M., Shohaimi, S., & Mohammadi, M. (2022). Global prevalence of falls in the older adults: A comprehensive systematic review and meta-analysis. *Journal of Orthopaedic Surgery and Research*, *17*(1), 334. https://doi.org/10.1186/s13018-022-03222-1

Salinas, E., Cueva, R., & Paz, F. (2020). A systematic review of user-centered design techniques. In A. Marcus & E. Rosenzweig (Eds.), *Design, User Experience, and Usability. Interaction Design* (Vol. 12200, pp. 253–267). Springer International Publishing. https://doi.org/10.1007/978-3-030-49713-2_18

Sandholdt, C. T., Cunningham, J., Westendorp, R. G. J., & Kristiansen, M. (2020). Towards inclusive healthcare delivery: Potentials and challenges of human-centred design in health innovation processes to increase healthy aging. *International Journal of Environmental Research and Public Health*, *17*(12), 4551. https://doi.org/10.3390/ijerph17124551

Santos-Lozada, A. R. (2023). Trends in deaths from falls among adults aged 65 years or older in the US, 1999-2020. *JAMA*, *329*(18), 1605. https://doi.org/10.1001/jama.2023.3054

Seppala, L. J., Petrovic, M., Ryg, J., Bahat, G., Topinkova, E., Szczerbińska, K., van der Cammen, T. J. M., Hartikainen, S., Ilhan, B., Landi, F., Morrissey, Y., Mair, A., Gutiérrez-Valencia, M., Emmelot-Vonk, M. H., Mora, M. Á. C., Denkinger, M., Crome, P., Jackson, S. H. D., Correa-Pérez, A., … van der Velde, N. (2021). STOPPFall (Screening Tool of Older Persons Prescriptions in older adults with high fall risk): A Delphi study by the EuGMS Task and Finish Group on fall-risk-increasing drugs. *Age and Ageing*, *50*(4), 1189–1199. https://doi.org/10.1093/ageing/afaa249

Seppala, L. J., van de Glind, E. M. M., Daams, J. G., Ploegmakers, K. J., de Vries, M., Wermelink, A. M. A. T., van der Velde, N., & EUGMS Task and Finish Group on Fall-Risk-Increasing Drugs. (2018). Fall-risk-increasing drugs: A systematic review and meta-analysis: III. Others. *Journal of the American Medical Directors Association*, *19*(4), 372.e1-372.e8. https://doi.org/10.1016/j.jamda.2017.12.099

Seppala, L. J., Wermelink, A. M. A. T., de Vries, M., Ploegmakers, K. J., van de Glind, E. M. M., Daams, J. G., van der Velde, N., & EUGMS task and Finish group on fall-risk-increasing drugs. (2018). Fall-risk-increasing drugs: A systematic review and meta-analysis: II. Psychotropics. *Journal of the American Medical Directors Association*, *19*(4), 371.e11-371.e17. https://doi.org/10.1016/j.jamda.2017.12.098

Shear, K., Rice, H., Garabedian, P. M., Bjarnadottir, R., Lathum, N., Horgas, A. L., Harle, C. A., Dykes, P. C., & Lucero, R. (2023). Management of fall risk among older adults in diverse primary care settings. *Journal of Applied Gerontology*, *42*(11), 2219–2232. https://doi.org/10.1177/07334648231185757

Shubert, T. E., Smith, M. L., Prizer, L. P., & Ory, M. G. (2014). Complexities of fall prevention in clinical settings: A commentary. *The Gerontologist*, *54*(4), 550–558. https://doi.org/10.1093/geront/gnt079

Sim, I., Gorman, P., Greenes, R. A., Haynes, R. B., Kaplan, B., Lehmann, H., & Tang, P. C. (2001). Clinical decision support systems for the practice of evidence-based medicine. *Journal of the American Medical Informatics Association: JAMIA*, *8*(6), 527–534. https://doi.org/10.1136/jamia.2001.0080527

Smye, S. W., & Frangi, A. F. (2021). Interdisciplinary research: Shaping the healthcare of the future. *Future Healthcare Journal*, *8*(2), e218–e223. https://doi.org/10.7861/fhj.2021-0025

Sossai, M. I., Pantoni, C. B. F., Gramani-Say, K., De Melo, M. L., Maciel, L. T., Lord, S. R., & Ansai, J. H. (2024). A case management strategy to reduce falls in older people with a history of falls: A randomized controlled trial. *Geriatric Nursing*, *59*, 301–305. https://doi.org/10.1016/j.gerinurse.2024.07.007

Spalluto, L. B., Bonnet, K., Sonubi, C., Ernst, L. L., Wahab, R., Reid, S. A., Agrawal, P., Gregory, K., Davis, K. M., Lewis, J. A., Berardi, E., Hartsfield, C., Selove, R., Sanderson, M., Schlundt, D., & Audet, C. M. (2023). Barriers to implementation of breast cancer risk assessment: The health care team perspective. *Journal of the American College of Radiology*, *20*(3), 342–351. https://doi.org/10.1016/j.jacr.2022.12.019

Steyerberg, E. W., & Harrell, F. E. (2016). Prediction models need appropriate internal, internal-external, and external validation. *Journal of Clinical Epidemiology*, *69*, 245–247. https://doi.org/10.1016/j.jclinepi.2015.04.005

Sucala, M., Ezeanochie, N. P., Cole-Lewis, H., & Turgiss, J. (2019). An iterative, interdisciplinary, collaborative framework for developing and evaluating digital behavior change interventions. *Translational Behavioral Medicine*, ibz109. https://doi.org/10.1093/tbm/ibz109

Tai, D., Li, E., Liu-Ambrose, T., Bansback, N., Sadatsafavi, M., & Davis, J. C. (2020). Patient-reported outcome measures (PROMs) to support adherence to falls prevention clinic recommendations: A qualitative study. *Patient Preference and Adherence*, *Volume 14*, 2105–2121. https://doi.org/10.2147/PPA.S269202

Tan, A. C. W., Clemson, L., Mackenzie, L., Sherrington, C., Roberts, C., Tiedemann, A., Pond, C. D., White, F., & Simpson, J. M. (2019). Strategies for recruitment in general practice settings: The iSOLVE fall prevention pragmatic cluster randomised controlled trial. *BMC Medical Research Methodology*, *19*(1), 236. https://doi.org/10.1186/s12874-019-0869-7

TechSmith. (n.d.). *Camtasia 9*. [Computer software]. https://www.techsmith.com/camtasia/

Tejeda, C. J., Garabedian, P. M., Rice, H., Samal, L., Latham, N. K., & Dykes, P. C. (2023). Development and usability testing of an exercise-based primary care fall prevention clinical decision support tool. *AMIA Annual Symposium Proceedings. AMIA Symposium*, *2023*, 699–708.

Ten Klooster, I., Wentzel, J., Sieverink, F., Linssen, G., Wesselink, R., & Van Gemert-Pijnen, L. (2022). Personas for better targeted eHealth technologies: User-centered design approach. *JMIR Human Factors*, *9*(1), e24172. https://doi.org/10.2196/24172

Teo, J. Y. C., & Wang, W. (2024). Interdisciplinary collaboration for chronic illness prevention and management through digital health interventions. *Interdisciplinary Nursing Research*, *3*(4), 199–200. https://doi.org/10.1097/NR9.0000000000000073

TestCafe. (n.d.). *End-to-end testing, simplified*. https://testcafe.io/

Thomas, D. R. (2006). A general inductive approach for analyzing qualitative evaluation data. *American Journal of Evaluation*, *27*(2), 237–246. https://doi.org/10.1177/1098214005283748

Tinetti, M. E., Gordon, C., Sogolow, E., Lapin, P., & Bradley, E. H. (2006). Fall-risk evaluation and management: Challenges in adopting geriatric care practices. *The Gerontologist*, *46*(6), 717–725. https://doi.org/10.1093/geront/46.6.717

Tomarken, A. J., & Serlin, R. C. (1986). Comparison of ANOVA alternatives under variance heterogeneity and specific noncentrality structures. *Psychological Bulletin*, *99*(1), 90–99. https://doi.org/10.1037/0033-2909.99.1.90

Trinkley, K. E., Blakeslee, W. W., Matlock, D. D., Kao, D. P., Van Matre, A. G., Harrison, R., Larson, C. L., Kostman, N., Nelson, J. A., Lin, C.-T., & Malone, D. C. (2019). Clinician preferences for computerised clinical decision support for medications in primary care: A focus group study. *BMJ Health & Care Informatics*, *26*(1), 0. https://doi.org/10.1136/bmjhci-2019-000015

Van de Loo, B., Heymans, M. W., Medlock, S., Boyé, N. D. A., van der Cammen, T. J. M., Hartholt, K. A., Emmelot-Vonk, M. H., Mattace-Raso, F. U. S., Abu-Hanna, A., van der Velde, N., & van Schoor, N. M. (2023). Validation of the AD*F*ICE_IT models for predicting falls and recurrent falls in geriatric outpatients. *Journal of the American Medical Directors Association*, *24*(12), 1996–2001. https://doi.org/10.1016/j.jamda.2023.04.021

Van De Loo, B., Linn, A. J., Medlock, S., Belimbegovski, W., Seppala, L. J., Van Weert, J. C. M., Abu-Hanna, A., Van Schoor, N. M., & Van Der Velde, N. (2024). AI-based decision support to optimize complex care for preventing medication-related falls. *Nature Medicine*, *30*(3), 620–621. https://doi.org/10.1038/s41591-023-02780-z

Van de Loo, B., Seppala, L. J., van der Velde, N., Medlock, S., Denkinger, M., de Groot, L. C., Kenny, R.-A., Moriarty, F., Rothenbacher, D., Stricker, B., Uitterlinden, A., Abu-Hanna, A., Heymans, M. W., & van Schoor, N. (2022). Development of the AD*F*ICE_IT models for predicting falls and recurrent falls in community-dwelling older adults: Pooled analyses of european cohorts with special attention to medication. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *77*(7), 1446–1454. https://doi.org/10.1093/gerona/glac080

Van Der Naald, N., Verbeek, F., Baden, D. N., Verbeek, A. J. M., Ham, W. H. W., Verbeek, J., Brummelkamp, E., Groenewoud, H., Stolwijk-van Niekerk, C., & Verbeek, A. (2024). Trends and projections in fall death in the Netherlands from 1990 to 2045. *Emergency Medicine Journal*, *41*(7), 404–408. https://doi.org/10.1136/emermed-2023-213073

Van der Velde, N., & Minhas, J. S. (2021). Appropriate deprescribing in older people: A challenging necessity commentary to accompany themed collection on deprescribing. *Age and Ageing*, *50*(5), 1516–1519. https://doi.org/10.1093/ageing/afab142

Van Maurik, I. S., Visser, L. N., Pel-Littel, R. E., van Buchem, M. M., Zwan, M. D., Kunneman, M., Pelkmans, W., Bouwman, F. H., Minkman, M., Schoonenboom, N., Scheltens, P., Smets, E. M., & van der Flier, W. M. (2019). Development and usability of ADappt: Web-based tool to support clinicians, patients, and caregivers in the diagnosis of mild cognitive impairment and alzheimer disease. *JMIR Formative Research*, *3*(3), e13417. https://doi.org/10.2196/13417

Van Rhyn, B., & Barwick, A. (2019). Health practitioners' perceptions of falls and fall prevention in older people: A metasynthesis. *Qualitative Health Research*, *29*(1), 69–79. https://doi.org/10.1177/1049732318805753

Van Velsen, L., Ludden, G., & Grünloh, C. (2022). The limitations of user- and human-centered design in an eHealth context and how to move beyond them. *Journal of Medical Internet Research*, *24*(10), e37341. https://doi.org/10.2196/37341

Van Weert, J. C. M., Jansen, J., De Bruijn, G.-J., Noordman, J., Van Dulmen, S., & Bensing, J. M. (2009). QUOTEchemo: A patient-centred instrument to measure quality of communication preceding chemotherapy treatment through the patient's eyes. *European Journal of Cancer*, *45*(17), 2967–2976. https://doi.org/10.1016/j.ejca.2009.06.001

Van Weert, J. C. M., van Munster, B. C., Sanders, R., Spijker, R., Hooft, L., & Jansen, J. (2016). Decision aids to help older people make health decisions: A systematic review and meta-analysis. *BMC Medical Informatics and Decision Making*, *16*, 45. https://doi.org/10.1186/s12911-016-0281-8

Van Wijngaarden, J. P., Dhonukshe-Rutten, R. A. M., van Schoor, N. M., van der Velde, N., Swart, K. M. A., Enneman, A. W., van Dijk, S. C., Brouwer-Brolsma, E. M., Zillikens, M. C., van Meurs, J. B. J., Brug, J., Uitterlinden, A. G., Lips, P., & de Groot, L. C. P. G. M. (2011). Rationale and design of the B-PROOF study, a randomized controlled trial on the effect of supplemental intake of vitamin B12 and folic acid on fracture incidence. *BMC Geriatrics*, *11*, 80. https://doi.org/10.1186/1471-2318-11-80

Vandervelde, S., Van Den Bosch, N., Vlaeyen, E., Dierckx De Casterlé, B., Flamaing, J., Belaen, G., Tuand, K., Vandendriessche, T., & Milisen, K. (2024). Determinants influencing the implementation of multifactorial falls risk assessment and multidomain interventions in community- dwelling older people: A systematic review. *Age and Ageing*, *53*(7), afae123. https://doi.org/10.1093/ageing/afae123

VanGeest, J. B., Johnson, T. P., & Welch, V. L. (2007). Methodologies for improving response rates in surveys of physicians: A systematic review. *Evaluation & the Health Professions*, *30*(4), 303–321. https://doi.org/10.1177/0163278707307899

VeiligheidNL (n.d.). *De Valanalyse*. https://www.veiligheid.nl/kennisaanbod/interventie/de-valanalyse

VeiligheidNL. (2023). *Infographic Valongevallen 65-plussers*. https://www.veiligheid.nl/kennisaanbod/infographic/infographic-valongevallen-65-plussers#:~:text=In%202023%20werden%20in%20totaal,val%20dan%20door%20een%20verkeersongeluk.

Velentzis, L. S., Freeman, V., Campbell, D., Hughes, S., Luo, Q., Steinberg, J., Egger, S., Mann, G. B., & Nickson, C. (2023). Breast cancer risk assessment tools for stratifying women into risk groups: A systematic review. *Cancers*, *15*(4), 1124. https://doi.org/10.3390/cancers15041124

Verbi Software. (n.d.). *MAXQDA*. https://www.maxqda.com/

Vial, S., Boudhraâ, S., & Dumont, M. (2022). Human-centered design approaches in digital mental health interventions: Exploratory mapping review. *JMIR Mental Health*, *9*(6), e35591. https://doi.org/10.2196/35591

Vieira, E. R., Palmer, R. C., & Chaves, P. H. M. (2016). Prevention of falls in older people living in the community. *BMJ*, i1419. https://doi.org/10.1136/bmj.i1419

Vincenzo, J. L., Hergott, C., Schrodt, L., Perera, S., Tripken, J., Shubert, T. E., & Brach, J. S. (2021). Physical therapists as partners for community fall risk screenings and referrals to community programs. *Frontiers in Public Health*, *9*, 672366. https://doi.org/10.3389/fpubh.2021.672366

Von Borries, G., & Wang, H. (2009). Partition clustering of high dimensional low sample size data based on values. *Computational Statistics & Data Analysis*, *53*(12), 3987–3998. https://doi.org/10.1016/j.csda.2009.06.012

Walden, A., Garvin, L., Smerek, M., & Johnson, C. (2020). User-centered design principles in the development of clinical research tools. *Clinical Trials*, *17*(6), 703–711. https://doi.org/10.1177/1740774520946314

Wall, S. A., Stevens, E., Vaughn, J., Bumma, N., Rosko, A. E., & Borate, U. (2022). Multidisciplinary approach to older adults with hematologic malignancies—A paradigm shift. *Current Hematologic Malignancy Reports*, *17*(1), 31–38. https://doi.org/10.1007/s11899-021-00646-0

Wang, Z., Hu, Y., & Peng, F. (2021). Long-term trends in unintentional fall mortality in China: A population-based age-period-cohort study. *Frontiers in Public Health*, *9*, 749295. https://doi.org/10.3389/fpubh.2021.749295

Westerbeek, L., De Bruijn, G.-J., Van Weert, H. C., Abu-Hanna, A., Medlock, S., & Van Weert, J. C. M. (2022). General Practitioners' needs and wishes for clinical decision support Systems: A focus group study. *International Journal of Medical Informatics*, *168*, 104901. https://doi.org/10.1016/j.ijmedinf.2022.104901

Westerbeek, L., Ploegmakers, K. J., De Bruijn, G.-J., Linn, A. J., Van Weert, J. C. M., Daams, J. G., Van Der Velde, N., Van Weert, H. C., Abu-Hanna, A., & Medlock, S. (2021). Barriers and facilitators influencing medication-related CDSS acceptance according to clinicians: A systematic review. *International Journal of Medical Informatics*, *152*, 104506. https://doi.org/10.1016/j.ijmedinf.2021.104506

White, R. M. (2020). *Implementation of a fall risk assessment tool in primary practice may decrease fall frequency in the aging population* [Liberty University]. https://digitalcommons.liberty.edu/doctoral/2768

Wilson, M., Keeley, J., Kingman, M., Wang, J., & Rogers, F. (2020). Current clinical utilization of risk assessment tools in pulmonary arterial hypertension: A descriptive survey of facilitation strategies, patterns, and barriers to use in the United States. *Pulmonary Circulation*, *10*(3), 1–10. https://doi.org/10.1177/2045894020950186

Witteman, H. O., Dansokho, S. C., Colquhoun, H., Coulter, A., Dugas, M., Fagerlin, A., Giguere, A. M., Glouberman, S., Haslett, L., Hoffman, A., Ivers, N., Légaré, F., Légaré, J., Levin, C., Lopez, K., Montori, V. M., Provencher, T., Renaud, J.-S., Sparling, K., … Witteman, W. (2015). User-centered design and the development of patient decision aids: Protocol for a systematic review. *Systematic Reviews*, *4*(1), 11. https://doi.org/10.1186/2046-4053-4-11

Witteman, H. O., Stahl, J. E., & on behalf of Interdisciplinary Solutions in Health Care Group†. (2013). Facilitating interdisciplinary collaboration to tackle complex problems in health care: Report from an exploratory workshop. *Health Systems*, *2*(3), 162–170. https://doi.org/10.1057/hs.2013.3

Witteman, H. O., Vaisson, G., Provencher, T., Chipenda Dansokho, S., Colquhoun, H., Dugas, M., Fagerlin, A., Giguere, A. M., Haslett, L., Hoffman, A., Ivers, N. M., Légaré, F., Trottier, M.-E., Stacey, D., Volk, R. J., & Renaud, J.-S. (2021). An 11-Item measure of user- and human-centered design for personal health tools (UCD-11): Development and validation. *Journal of Medical Internet Research*, *23*(3), e15032. https://doi.org/10.2196/15032

World Health Organization (WHO). (2024). *Ageing and health*. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

World Health Organization (WHO). (2021). *Falls*. https://www.who.int/news-room/fact-sheets/detail/falls

World Health Organization (WHO). (n.d.). *Netherlands*. https://data.who.int/countries/528

Zhang, Z., Brazil, J., Ozkaynak, M., & Desanto, K. (2020). Evaluative research of technologies for prehospital communication and coordination: A systematic review. *Journal of Medical Systems*, *44*(5), 100. https://doi.org/10.1007/s10916-020-01556-z

English Summary

Aims of this dissertation

Digital health interventions are promising for improving the quality of care in various health contexts, such as for preventing falls in older adults. Falls can reduce the quality of life in older adults (65+) and increase medical costs for the health care system, making falls a global health problem. Falls are a result of several interacting risk factors and targeting those that are modifiable, such as reduced mobility and medication use, can significantly prevent falls. Interventions, such as multifactorial falls risk assessments (i.e., to identify risk factors for falling) and clinical decision support systems (CDSS; i.e., to make guideline-based clinical decisions), can support health care professionals (HCPs) in the optimal delivery of falls prevention care. However, these interventions are often not developed for use in real-life practice settings, resulting in several unintended barriers, such as difficulty of use, incompatibility with the context of use, and poor communication and coordination between HCPs. These barriers inevitably hinder the use and, in turn, adoption of interventions by HCPs.

User-centered design (UCD) has been shown to improve the use of digital health interventions for users in real-life practice settings. UCD follows an iterative development cycle that relies on the early and continuous involvement of prospective users of an intervention. This cycle has three steps including (1) understanding user needs; (2) developing and/or refining interventions based on these needs; and (3) observing prospective users interactions for further refinement of interventions. Despite its effectiveness, studies have highlighted the need to further improve UCD to promote broader adoption of digital health interventions by users. Given this context, this dissertation has three aims:

1. Set new standards for examining the needs of prospective users of digital health interventions.
2. Improve the development and refinement efforts of UCD developed digital health interventions.
3. Investigate the effectiveness, user experience, and implementation of UCD developed digital health interventions in real-life practice settings.

To achieve these aims, this dissertation is divided into three parts. Part 1 (aim 1) is presented in chapters 2 and 3. Part 2 (aim 2) is presented in chapters 4 and 5. Lastly, part 3 (aim 3) is presented in chapter 6.

Principal findings

Part 1: New standards for examining the needs of prospective users

Chapter 2 – Combining UCD and behavioral theory for personas-construction

Chapter 2 showcased an enhanced approach to personas-construction (i.e., constructing fictitious user descriptions) in which UCD and behavioral theory were combined to uncover the external and intrinsic user characteristics of prospective users of a digital health intervention, called the Fall Analysis 2.0 (i.e., an online multifactorial falls risk assessment). These insights were used to inform requirements for the development of this intervention. For this, behavioral theory and UCD driven survey data from primary care-based HCPs (n = 31) was collected to perform a multivariate cluster analysis technique. Differences between the six identified clusters on 68 clustering variables were examined using non-parametric analyses and computational methods. Significant differences between these clusters were observed in 20 clustering variables, such as differences in behavioral beliefs, normative beliefs, situations for use, and environments for use. These variables were used to construct a total of six personas, each representing a prospective user of the Fall Analysis 2.0. The aggregated external user characteristics of personas helped to guide the design of the Fall Analysis 2.0, whereby intrinsic user characteristics were matched with relevant behavior change techniques to inform implementation. A total of four key design requirements (e.g., enhance assessment efficiency) and 14 behavior change techniques (e.g., planning coping responses) were identified using the personas. The behavior change techniques were applied in a training module for the Fall Analysis 2.0. Therefore, this study demonstrated that embedding behavioral theory in personas-construction is useful for establishing requirements for the design and implementation of digital health interventions that are in line with the needs of users.

Chapter 3 – Deeper understanding into user needs using journey mapping

Chapter 3 explored whether a deeper understanding into the needs of prospective users of the Fall Analysis 2.0 could be achieved using the UCD method of journey mapping (i.e., pathways visualizing user engagement). To assess this, online focus groups and interviews (N = 45) were conducted with physical therapists (n = 15), district nurses (n = 9), occupational therapists (n = 7), pharmacists (n = 6), nurse practitioners (n = 5), podiatrists (n = 2) and one general practitioner. HCPs were asked about their interactions, experiences, needs, and barriers with regards to multidisciplinary falls prevention care. These needs were visualized into a journey map depicting the desired future state of multidisciplinary care pathways for falls prevention by primary care-based HCPs (i.e., falls risk stratification, multifactorial falls risk assessment, and management of multidomain interventions targeting two or more falls risk factors). Journey mapping uncovered several needs for effective multidisciplinary falls prevention care including: a dedicated case manager for older adults at high risk of falling, a small multidisciplinary care team for the assessment, preparatory patient information prior to the assessment, access to resources to facilitate communication between HCPs, and a reduction in workload. Therefore, this study demonstrated how journey mapping complemented personas-construction by providing insight into user needs at different touch points with the digital health intervention (i.e., falls risk stratification, multifactorial falls risk assessment, and multidomain intervention).

Part 2: Improve the development and refinement efforts of interventions

Chapter 4 – Interdisciplinary expertise in UCD driven digital health interventions

Chapter 4 described the development of a clinical decision support system (CDSS), called the AD*F*ICE_IT CDSS, to support HCPs in personalized and optimum deprescribing of falls-risk increasing drugs (FRIDs) in older adults. This CDSS was developed together with an interdisciplinary research team from communication science, epidemiology, geriatrics, and medical informatics. Knowledge from communication science was used to examine

the needs of HCPs which included a literature on risk communication needs, a systematic review on barriers and facilitators, a European survey (n = 581), semi-structured interviews (n = 19) and two separate usability testing rounds (n = 11) with HCPs. The results from these studies informed the design requirements for the user interface of the CDSS which included limiting repeated and uninformative alerts, prioritizing the inclusion of easy-to-use features for fast-paced clinical environments, providing actionable deprescribing recommendations, offering information transparency, visualizing the patient's falls risk estimation and reducing medical terminology. Knowledge from epidemiology was used to develop and validate a falls risk prediction model to enable the personalized estimation of a patient's fall risk within 12 months in the CDSS. Knowledge from geriatrics and medical informatics was used to formalize deprescribing guidelines into clinical rules for the CDSS, which covered 22 classes of FRIDs. Medical informatics was in addition used to develop the software for the CDSS which included a modular architecture, open source, and good security. Thus, chapter 4 highlighted the importance of an interdisciplinary research team for enhancing the usefulness and usability of UCD driven digital health interventions in real-life practice settings.

Chapter 5 – Enhanced approach to prioritizing usability problems

Chapter 5 evaluated the usability of the Fall Analysis 2.0 prototype and examined how the prioritization of identified usability problems can be enhanced to better inform refinement efforts in digital health interventions. A usability testing with think-aloud was conducted with primary care-based HCPs (N = 16) using fictional patient cases and clinically relevant task scenarios in the Fall Analysis 2.0. Identified usability problems were analyzed using an adapted Augmented Classification Scheme for classifying and prioritizing usability problems in which the severity ratings of usability problems were based on the problem's impact on the secondary (i.e., patient care outcomes) instead of primary user experience (i.e., task outcomes). A total of 11 usability problems were identified by HCPs. The majority of problems happened due to poorly noticeable or discernable cognitive affordances (e.g., not being able to locate the 'start button' to start a new assessment). Four out of the 11 usability problems received the highest severity rating (i.e., usability catastrophe). Not solving these problems

(e.g., forgetting to click the 'save button') prior to full-scale development of the Fall Analysis 2.0 can have a direct negative impact on the patients wellbeing in clinical practice (e.g., a potential risk factor for falls is left untreated). These usability problems received the highest priority for the refinements efforts of the Fall Analysis 2.0. Therefore, chapter 5 showcased how an adapted Augmented Classification Scheme, in which the severity ratings of usability problems are based on the problems impact on the secondary (i.e., patient care outcomes) instead of primary user experience (i.e., task outcomes), can optimize intervention refinement efforts by prioritizing the solving of problems that pose a severe threat to patient care.

Part 3: Investigate developed digital health interventions in real-life practice settings

Chapter 6 – Examining the effectiveness, user experience, and implementation of UCD interventions

In chapter 6, the effectiveness, user experience, and implementation of the Fall Analysis 2.0 was evaluated in primary care in the Netherlands. Specifically, a hybrid type 2 effectiveness-implementation study was conducted with 19 HCPs from 15 practices, who were randomly assigned to either the intervention (i.e., Fall Analysis 2.0) or control (i.e., usual care) group. Older adults were community-dwelling (65+) and at high risk of falling (36 intervention, 27 control). Primary outcomes included differences in the falls risk management behavior of HCPs (i.e., rate of fully completed multifactorial falls risk assessments) and motivation to adhere to falls prevention advice in older adults. In the intervention group, HCPs conducted multifactorial falls risk assessments in older adults using the Fall Analysis 2.0. In the control group, HCPs conducted multifactorial falls risk assessments in older adults following usual care, such as the Fall Analysis 1.0 (i.e., a paper-based multifactorial falls risk assessment). All HCPs and older adults completed baseline and post-consultation questionnaires. Additionally, user generated data was collected from HCPs in the intervention group only. The results showed that HCPs using the Fall Analysis 2.0 carried out significantly more fully completed multifactorial falls risk assessments in older adults compared to HCPs providing usual care.

Additionally, HCPs using the Fall Analysis 2.0 rated the tool highly for user experience, and highlighted that sustainable implementation of the tool in real-life practice is contingent upon HCP reimbursement and interoperability with electronic health records. No significant difference in adherence-related motivation was observed between older adults in the intervention versus control group. To conclude, the UCD developed Fall Analysis 2.0 is promising for enhancing the delivery and, in turn, quality of falls prevention in primary care.

Implications of the findings

Implications for theory and methods

This dissertation showcased that constructing behavior theory driven personas and a visual journey map can provide a comprehensive understanding of user needs, as it provides insight into the external user characteristics for improving user experience, intrinsic user characteristics for improving implementation, and desired future state of the digital health intervention for improving optimal configuration in practice. This comprehensive understanding can inform adoption requirements at the individual (i.e., through improved user experience), group (i.e., through tailored implementation strategies), and stakeholder (i.e., through interoperability) level, which is vital for the sustainability of interventions in practice. Additionally, this dissertation illustrated how the continuous involvement of prospective users of interventions can prevent pitfalls early on and uncover mismatched user needs. Such a rigorous UCD approach can facilitate ongoing improvements in digital health interventions, which can further enhance their adoption in practice. Furthermore, this dissertation demonstrated how an interdisciplinary research team can further augment the usefulness and usability of complex, UCD driven digital health interventions for HCPs, such as in the case of the AD*F*ICE_IT CDSS to support deprescribing and joint medication management of falls risk increasing drugs in older adults. Lastly, this dissertation showed how the secondary user experience, which refers to the outcomes experienced by patients (i.e., secondary users) as a result of the intervention, can be incorporated in digital health interventions. Specifically, digital health

interventions can provide HCPs with treatment plans in patient-friendly language to facilitate better provider-patient interactions. In turn, digital health interventions can ensure that the most critical usability problems affecting patient care are tackled first during refinement efforts by basing the severity rating of problems on the impact on the secondary (i.e., patient) instead of primary (i.e., HCP) user experience.

Implications for practice

This dissertation presented the usefulness of UCD for developing digital health interventions in both single-care and multidisciplinary care contexts. With respect to multidisciplinary care contexts, applying a rigorous UCD approach ensured that the Fall Analysis 2.0 met the needs of HCPs as a whole (e.g., receiving preparatory patient information) and from each discipline specifically (e.g., ensuring good usability in patient homes for occupational therapists and in clinical practice for pharmacists). Additionally, the results from this dissertation have several implications for developers seeking to develop or enhance existing digital health interventions. Specifically, the findings suggest that interventions should decrease the cognitive effort of the clinical task, systematically guide HCPs through the clinical task, and provide actionable recommendations for reducing risk.

Implications for falls prevention

The findings of this dissertation demonstrate that the implementation of clinical guidelines with regards to falls prevention can be enhanced through UCD driven digital health interventions, providing important insights for stakeholders and policymakers part of the Dutch national multidomain falls prevention program. In this dissertation, the enhanced user experience of the Fall Analysis 2.0 facilitated more fully completed evidence-based multifactorial falls risk assessments in older adults. This can, in turn, increase the quality of falls prevention for older adults at high risk of falling, as falls risk factors are assessed by HCPs per the guidelines resulting in better targeted multidomain interventions in these adults. In developing digital falls prevention interventions, stakeholders and policymakers should prioritize the incorporation of time-saving functionalities (e.g., automated assessment results), and ensure their interoperability with the electronic health records of HCPs.

General conclusion

This dissertation augmented UCD and showcased its usefulness for developing two digital falls prevention interventions (i.e., the Fall Analysis 2.0 and AD*F*ICE_IT CDSS). This dissertation concludes that the promising effects of UCD driven digital health interventions can be realized through a comprehensive needs assessment embedded with behavioral theory, continuous user involvement, interdisciplinary expertise, and the incorporation of the secondary user experience (i.e., the experience of patients).

Nederlandse samenvatting

Doel van dit proefschrift

Digitale gezondheidsinterventies zijn veelbelovend om de kwaliteit van de zorg te verbeteren, zoals het voorkomen van vallen bij 65-plussers. Een val kan een grote negatieve impact hebben op het dagelijks functioneren van 65-plussers en leiden tot hogere zorgkosten. Dit maakt vallen een wereldwijd gezondheidsprobleem. Een val is het gevolg van verschillende samenhangende risicofactoren. Door in te spelen op factoren die beïnvloedbaar zijn, zoals verminderde mobiliteit en medicijngebruik, kan het risico op een val verminderden. Interventies zoals multifactoriële valrisicobeoordelingen (d.w.z. het identificeren van factoren die bijdragen aan het verhogen van het valrisico) en klinische beslissingsondersteunende systemen (KBoS; d.w.z. een systeem die zorgverleners ondersteunt in het nemen van klinische beslissingen) kunnen zorgverleners ondersteunen bij valpreventie. Deze interventies zijn echter vaak ontwikkeld met als doel om getest te worden in bijvoorbeeld een RCT, en niet voor gebruik in de dagelijkse praktijk. Dit leidt vaak tot verschillende problemen met de bruikbaarheid, zoals problemen met de gebruiksvriendelijkheid of en gebrekkige aansluiting op de context waarin de interventie wordt toegepast. Daarnaast houden meeste interventies geen rekening met de samenwerking tussen verschillende zorgverleners. Deze problemen beïnvloeden de adoptie van digitale gezondheidsinterventies negatief.

User-Centered Design (UCD) heeft aangetoond het gebruik en daarmee de adoptie van digitale gezondheidsinterventies in de praktijk te verbeteren. UCD volgt een iteratief proces dat gebaseerd is op de continue betrokkenheid van de beoogde gebruiker bij de ontwikkeling van een interventie. Dit proces bestaat uit drie stappen: (1) het onderzoeken en begrijpen van gebruikersbehoeften; (2) het ontwikkelen en/of verbeteren van de interventie op basis van deze behoeften; en (3) het observeren van interacties tussen de gebruiker en de interventie met als doel de bruikbaarheid en effectiviteit te verbeteren. Hoewel UCD waardevol is gebleken, benadrukken studies de noodzaak tot verdere optimalisatie van UCD om de adoptie van digitale gezondheidsinterventies verder te stimuleren.

Om die reden zijn de volgende doelstellingen geformuleerd:

1. Het ontwikkelen van nieuwe standaarden voor het onderzoeken van de behoeften van beoogde gebruikers van digitale gezondheidsinterventies.
2. Het optimaliseren van de ontwikkel- en verbeterprocessen van UCD-gebaseerde digitale gezondheidsinterventies.
3. Onderzoek naar ontwikkelde digitale gezondheidsinterventies in praktijksituaties.

Om deze doelstellingen te bereiken, is dit proefschrift opgedeeld in drie delen. Doelstelling 1 wordt behandeld in hoofdstukken 2 en 3 (deel 1). Doelstelling 2 wordt behandeld in hoofdstukken 4 en 5 (deel 2). Tot slot wordt doelstelling 3 behandeld in hoofdstuk 6 (deel 3).

Belangrijkste bevindingen

Deel 1: Het ontwikkelen van nieuwe standaarden voor het onderzoeken van de behoeften van beoogde gebruikers van digitale gezondheidsinterventies

Hoofdstuk 2 – Ontwikkeling van personas gebaseerd op gecombineerde inzichten uit UCD en gedragswetenschappen

Hoofdstuk 2 besprak een verbeterde aanpak voor het opstellen van personas (d.w.z. fictieve gebruikersprofielen), waarbij UCD werd geïnformeerd door theorie om zowel externe als intrinsieke gebruikerskenmerken van beoogde gebruikers van een digitale gezondheidsinterventie te identificeren. Deze aanpak werd toegepast in het kader van de ontwikkeling van de verbeterde Valanalyse, een online, multifactoriële valrisicobeoordelingsinstrument. Hiervoor werden personas ingezet om de gebruiksvriendelijkheid van het systeem te verbeteren. Voor het ontwikkelen van personas werd een vragenlijst uitgezet bij zorgverleners uit de eerste lijn (N = 31), waarna een multivariate clusteranalyse werd uitgevoerd. De verschillen tussen de zes geïdentificeerde clusters op 68 clusteringvariabelen werden geanalyseerd

met behulp van niet-parametrische toetsen en computationele analysemethoden (bijv. Kruskal-Wallis-toets en exacte toets van Fisher). Er werden significante verschillen gevonden op 20 variabelen, waaronder attitudes, normatieve overtuigingen, en gebruikerscontext. Op basis van deze resultaten werden zes personas ontwikkeld, die elk representatief zijn voor een beoogde gebruiker van de verbeterde Valanalyse, Valanalyse 2.0. De externe gebruikerskenmerken van de personas droegen bij aan het ontwerp van de Valanalyse 2.0, terwijl de intrinsieke kenmerken werden gekoppeld aan passende strategieën voor gedragsverandering ter ondersteuning van de implementatie. Dit resulteerde in vier belangrijke ontwerpeisen (o.a. het verbeteren van de beoordelingsefficiëntie) en veertien gedragsbeïnvloedingsstrategieën (bijv. het gebruik van als-dan strategieën). Deze studie toonde aan dat een theoretische basis voor het toepassen van UCD een waardevolle aanpak vormt voor het ontwikkelen van personas. Deze personas geven richting aan ontwerp- en implementatievereisten van digitale gezondheidsinterventies die aansluiten bij de behoeften van gebruikers.

Hoofdstuk 3 – Verdiepend inzicht in gebruikersbehoeften met behulp van journey mapping

Hoofdstuk 3 onderzocht of de UCD methode journey mapping (d.w.z. visuele weergave van gebruikersinteracties) kan bijdragen aan een beter begrip van de gebruikersbehoeften van de Valanalyse 2.0. Voor het ontwikkelen van de journey map werden online focusgroepen en interviews (N = 45) gehouden met fysiotherapeuten (n = 15), wijkverpleegkundigen (n = 9), ergotherapeuten (n = 7), apothekers (n = 6), praktijkondersteuners ouderenzorg (n = 5), podotherapeuten (n = 2) en één huisarts. Zorgverleners werden gevraagd naar hun interacties, ervaringen, behoeften en barrières met betrekking tot multidisciplinaire valpreventie. Deze behoeften werden gevisualiseerd in een journey map die de gewenste, toekomstige multidisciplinaire zorgpaden voor valpreventie binnen de eerstelijnszorg weergaf. Deze zorgpaden bevatten o.a., de valrisicostratificatie, multifactoriële valrisicobeoordeling en het managen van interventies die zich richten op meerdere risicofactoren voor vallen (d.w.z. multidomeininterventie). Journey mapping bracht diverse behoeften

aan het licht voor effectieve multidisciplinaire valpreventie. Deze omvatten onder meer de inzet van een toegewijde casemanager voor 65-plussers met een verhoogd valrisico, een compact multidisciplinair zorgteam voor de beoordeling, het verstrekken van voorbereidende patiëntinformatie voorafgaand aan de beoordeling, toegang tot hulpmiddelen ter ondersteuning van de communicatie tussen zorgverleners, en een verminderde werkdruk. Deze studie liet zien hoe journey mapping een aanvulling vormt op de inzichten die personas bieden, door inzichtelijk te maken welke gebruikersbehoeften op specifieke momenten in het zorgpad ontstaan tijdens het gebruik van de Valanalyse.

Deel 2: Het optimaliseren van de ontwikkel- en verbeterprocessen van UCD-gebaseerde digitale gezondheidsinterventies

Hoofdstuk 4 – Interdisciplinaire expertise in UCD gedreven digitale gezondheidsinterventies

Hoofdstuk 4 beschreef de ontwikkeling van een KBoS, genaamd AD*F*ICE_IT, dat zorgverleners ondersteunt bij het gepersonaliseerd en verantwoord afbouwen van valrisico-verhogende medicatie bij 65-plussers. Het systeem werd ontwikkeld door een interdisciplinair onderzoeksteam met expertise uit communicatiewetenschap, epidemiologie, geriatrie en medische besliskunde. Kennis uit de communicatiewetenschap werd ingezet om de behoeften van zorgverleners in kaart te brengen. Hiervoor werden verschillende methodes toegepast waaronder een systematische review van factoren die het gebruik van een KBoS belemmeren of bevorderen, een vragenlijst onder zorgverleners van meerdere Europese landen (N = 581), semigestructureerde interviews met verschillende zorgverleners (N = 19) en twee gebruikerstests met zorgverleners (N = 11). De resultaten hiervan vormden de basis voor het ontwerp van het KBoS, waaronder het beperken van herhaalde of irrelevante meldingen, prioritering van gebruiksgemak in drukke klinische settingen, het bieden van uitvoerbare afbouwadviezen, transparantie van informatie, visualisatie van het individuele valrisico en vermijden van medisch jargon. Kennis uit de epidemiologie werd gebruikt voor de ontwikkeling en validatie van een model dat het persoonlijke valrisico binnen 12 maanden kon voorspellen.

Binnen het project richtte de expertise vanuit de geriatrie en medische besliskunde zich op het formaliseren van afbouwrichtlijnen aan de hand van klinische beslisregels, die betrekking hadden op 22 klassen van valrisico-verhogende medicatie. Daarnaast werd met behulp van medische besliskunde de software ontwikkeld, met aandacht voor een modulaire architectuur, open source en goede beveiliging. Hoofdstuk 4 liet het belang van een interdisciplinair onderzoeksteam zien voor het verbeteren van de bruikbaarheid en toepasbaarheid van UCD gedreven digitale gezondheidsinterventies in de praktijk.

Hoofdstuk 5 – Verbeterde aanpak voor het prioriteren van bruikbaarheidsproblemen

Hoofdstuk 5 evalueerde de bruikbaarheid van het Valanalyse 2.0-prototype en onderzocht hoe de prioritering van geïdentificeerde problemen met de bruikbaarheid kan worden geoptimaliseerd om aanpassingen binnen digitale gezondheidsinterventies beter te onderbouwen. Een think-aloud werd uitgevoerd met zorgverleners uit de eerstelijn (N = 16), die aan de hand van een fictieve patiënt casuïstiek verschillende taken moesten uitvoeren binnen de Valanalyse 2.0. Geïdentificeerde bruikbaarheidsproblemen werden geanalyseerd met behulp van een aangepaste Augmented Classification Scheme, waarbij de ernst van de problemen met de bruikbaarheid werd beoordeeld op basis van de impact op de secundaire gebruiker (in het geval van deze studie: patiëntuitkomsten) in plaats van primaire gebruikerservaring (in het geval van deze studie: taakuitkomsten). In totaal werden 11 bruikbaarheidsproblemen geïdentificeerd door zorgverleners. De meeste problemen ontstonden door stappen in de Valanalyse 2.0 die niet duidelijk zichtbaar of herkenbaar waren voor de gebruiker (bijv. het niet kunnen vinden van de ‘startknop’ om een nieuwe beoordeling te starten). Vier van de 11 problemen met de bruikbaarheid kregen de hoogste score wat betekende dat het niet oplossen van deze problemen (bijv. vergeten op de ‘opslaan-knop’ te klikken) een directe negatieve impact kan hebben op het welzijn van patiënten (bijv. een potentieel valrisico blijft onbehandeld). Deze problemen kregen de hoogste prioriteit in het verbeteren van de Valanalyse 2.0. Hoofdstuk 5 liet zien hoe een aangepaste versie van het Augmented Classification Scheme kan bijdragen aan het optimaliseren

van digitale interventies. In deze aanpak werd de ernst van bruikbaarheidsproblemen bepaald op basis van hun impact op secundaire in plaats van primaire uitkomsten, waardoor problemen met directe gevolgen voor de patiëntenzorg konden worden geprioriteerd.

Deel 3: Onderzoek naar ontwikkelde digitale gezondheidsinterventies in praktijksituaties

Hoofdstuk 6 – Onderzoek naar de effectiviteit, gebruikerservaring en implementatie van UCD-gebaseerde interventies

In hoofdstuk 6 werd de effectiviteit, gebruikerservaring en implementatie van de Valanalyse 2.0 geëvalueerd in de eerstelijnszorg in Nederland. Er werd een hybride type 2 effectiviteits-implementatiestudie uitgevoerd met verschillende zorgverleners (N=19) uit diverse praktijken (N=15), die willekeurig werden toegewezen aan de interventiegroep (d.w.z. Valanalyse 2.0) of controlegroep (d.w.z. standaardzorg). In totaal namen 63 (36 interventie, 27 controle) zelfstandig wonende 65-plussers met een verhoogd valrisico deel aan de studie. Primaire uitkomsten waren het valrisicomanagementgedrag van de zorgverleners, gemeten aan de hand van het aantal volledig afgeronde multifactoriële valrisicobeoordelingen, en de motivatie van patiënten (65-plussers) om valpreventieadvies op te volgen. Zorgverleners in de interventiegroep maakten gebruik van de Valanalyse 2.0, terwijl zorgverleners in de controlegroep de standaardzorg toepasten, waaronder de Valanalyse 1.0 (d.w.z. een papieren multifactoriële valrisicobeoordeling). Alle zorgverleners en patiënten vulden voor en na het consult vragenlijsten in. Daarnaast werd gebruikersdata verzameld van zorgverleners in de interventiegroep. De resultaten toonden aan dat zorgverleners die de Valanalyse 2.0 gebruikten significant meer volledig afgeronde multifactoriële valrisicobeoordelingen uitvoerden dan de controlegroep. Zorgverleners beoordeelden de Valanalyse 2.0 bovendien positief op gebruikerservaring en benadrukten dat duurzame implementatie in de praktijk afhankelijk is van vergoeding en interoperabiliteit met elektronische patiëntendossiers. Er werd geen significant verschil gevonden in motivatie met betrekking tot therapietrouw tussen patiënten in de interventie- en controlegroep. Deze studie liet zien dat de ontwikkelde

Valanalyse 2.0 veelbelovend is voor het verbeteren van de uitvoering en daarmee de kwaliteit van valpreventie in de eerstelijn.

Implicaties van de bevindingen

Implicaties voor theorie en methoden

Dit proefschrift laat zien dat de UCD-benadering een effectieve en waardevolle methode is voor het ontwikkelen van digitale gezondheidsinterventies in de eerstelijnszorg die aansluiten bij de behoeften van de gebruiker. Het gebruik van theorie bij het ontwikkelen van persona's biedt diepgaander inzicht in behoeften rond ontwerp en implementatie dan wanneer uitsluitend wordt uitgegaan van demografische kenmerken zoals in eerder onderzoek gebruikelijk was. Gecombineerd met de inzichten uit de journey map biedt dit een volledig beeld dat bijdraagt aan het verbeteren van gebruikerservaringen op individueel niveau, het afstemmen van implementatiestrategieën op groepsniveau, en het faciliteren van technische integratie op het niveau van betrokken stakeholders. De continue betrokkenheid van beoogde gebruikers voorkomt mismatches tussen ontwerp en praktijkbehoeften, en verhoogt de toepasbaarheid van de interventie. Daarbij onderstreept dit proefschrift het belang van een interdisciplinair team bij de ontwikkeling van digitale gezondheidsinterventies, zoals aangetoond in de samenwerking binnen het AD*F*ICE_IT KBoS. Tot slot maakt dit proefschrift duidelijk dat het integreren van de secundaire gebruikerservaring (ervaring van patiënten) een veelbelovende nieuwe toepassing is in de ontwerp- en beoordelingsprocessen van digitale gezondheidsinterventies.

Implicaties voor de praktijk

Dit proefschrift toont aan dat UCD waardevolle inzichten biedt voor het ontwikkelen van digitale gezondheidsinterventies in zowel enkelvoudige als multidisciplinaire zorgcontexten. In een multidisciplinaire zorgcontext, zorgt deze aanpak ervoor dat de Valanalyse 2.0 aansluit bij de behoeften van zorgverleners (bijv. het ontvangen van voorbereidende patiëntinformatie) en

de discipline waarin deze zorgverlener werkzaam is. Zo biedt de Valanalyse 2.0 bijvoorbeeld relevante functies voor zowel ergotherapeuten (in de thuissituatie) als apothekers (in de klinische praktijk). Daarnaast hebben de resultaten van dit proefschrift verschillende implicaties voor ontwikkelaars die digitale gezondheidsinterventies willen ontwikkelen of verbeteren. Digitale interventies zouden gericht moeten zijn op het verlagen van cognitieve belasting, het systematisch ondersteunen van klinische besluitvorming, en het bieden van uitvoerbare aanbevelingen.

Implicaties voor valpreventie

De implementatie van klinische richtlijnen voor valpreventie kan worden ondersteund door digitale, UCD gedreven gezondheidsinterventies. Dit biedt belangrijke aanknopingspunten voor stakeholders en beleidsmakers binnen de Nederlandse ketenaanpak valpreventie. Bij het ontwikkelen van digitale valpreventie interventies zouden stakeholders en beleidsmakers daarnaast prioriteit moeten geven aan het integreren van tijdbesparende functionaliteiten (bijv. automatische beoordelingsresultaten) en moeten zorgen voor interoperabiliteit met de elektronische patiëntendossiers van zorgverleners. De Valanalyse 2.0 blijkt in staat om multifactoriële valrisicobeoordelingen in de eerstelijnszorg te ondersteunen en heeft potentieel om de kwaliteit van valpreventie bij 65-plussers met een verhoogd valrisico te verbeteren.

Algemene conclusie

Dit proefschrift toont de meerwaarde aan van de UCD-benadering voor de ontwikkeling van digitale gezondheidsinterventies in de eerstelijnszorg, specifiek in de context van valpreventie. Aan de hand van twee praktijkgerichte toepassingen, de Valanalyse 2.0 en het AD*F*ICE_IT KBoS, is aangetoond hoe UCD-gedreven interventies kunnen bijdragen aan effectievere en beter ingebedde zorgoplossingen. Dit proefschrift draagt daarnaast bij aan de verdere ontwikkeling van de UCD-methodiek door theoriegestuurde benaderingen te introduceren voor het identificeren van gebruikersbehoeften en het prioriteren van ontwerpkeuzes op basis van

hun impact op de patiëntenzorg. Door gedragswetenschappelijke theorieën, journey mapping en de integratie van secundaire gebruikerservaring (d.w.z. de ervaring van patiënten), voortdurende betrokkenheid van gebruikers, interdisciplinaire samenwerking te combineren, worden praktische handvatten geboden om UCD-toepassingen contextspecifieker, gebruiksvriendelijker en beter implementeerbaar te maken.

Author contributions

Chapter 2. Combining user-centered design and behavioral theory to enhance health technologies: A personas-based approach for a primary care-based multifactorial falls risk assessment tool

Sara S. Groos (SG), Annemiek J. Linn (AL), Judith I. Kuiper (JK), Natasja M. van Schoor (NvS), Nathalie van der Velde (NvdV), Julia C. M. van Weert (JvW).

Conceptualization: SG, AL, JK, NvS, NvdV, JvW. Data collection: SG. Data analysis: SG. Methodology: SG. Writing – original draft: SG. Writing – review & editing: AL, JK, NvS, NvdV, JvW.

Chapter 3. Multidisciplinary care pathways for falls prevention in older adults: Visualizing the needs of primary care-based health care professionals

Sara S. Groos (SG), Stefanie M. Tan (ST), Annemiek J. Linn (AL), Judith I. Kuiper (JK), Natasja M. van Schoor (NvS), Julia C. M. van Weert (JvW), Nathalie van der Velde (NvdV).

Conceptualization: SG, AL, JK, NvS, NvdV, JvW. Data collection: SG, ST. Data analysis: SG, ST. Methodology: SG, ST. Writing – original draft: SG, ST. Writing – review & editing: AL, JK, NvS, NvdV, JvW.

Chapter 4. Development of the ADFICE_IT clinical decision support system to assist deprescribing of fall-risk increasing drugs: A user-centered design approach

Sara S. Groos (SG), Kelly K. de Wildt (KdW), Bob van de Loo (BvdL), Annemiek J. Linn (AL), Stephanie Medlock (SM), Kendrick M. Shaw (KS), Eric K. Herman (EH), Lotta J. Seppala (LS), Kim J. Ploegmakers (KP), Natasja M. van Schoor (NvS), Julia C. M. van Weert (JvW), Nathalie van der Velde (NvdV).

Conceptualization: NvdV, NvS, SM, and JvW. Data collection: SG, KdW, BvdL, AL, SM, LS, KP, LW. Data analysis: SG, KdW, BvdL, AL, SM, LS, KP, LW, KS, EH. Methodology: SG, KdW, BvdL, AL, SM, LS, KP, LW, KS, EH. Writing – original draft: SG. Writing – review & editing: KdW, BvdL, AL, SM, KS, EH, LS, KP, NvS, JvW, NvdV.

Chapter 5. Shifting from the primary to secondary user experience: An optimized approach to usability problem prioritization in health technologies

Sara S. Groos (SG), Judith I. Kuiper (JK), Natasja M. van Schoor (NvS), Julia C. M. van Weert (JvW), Nathalie van der Velde (NvdV), Annemiek J. Linn (AL).

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Chapter 6. Investigating a user-centered design driven multifactorial falls risk assessment tool in primary care: A randomized effectiveness-implementation study

Sara S. Groos (SG), Judith I. Kuiper (JK), Natasja M. van Schoor (NvS), Julia C. M. van Weert (JvW), Annemiek J. Linn (AL), Nathalie van der Velde (NvdV).

Conceptualization: SG, AL, JK, NvS, NvdV, JvW. Data collection: SG. Data analysis: SG. Methodology: SG. Writing – original draft: SG. Writing – review & editing: AL, JK, NvS, NvdV, JvW

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About the author

Sara S. Groos was born on 5 October 1994 in Luxembourg. She completed her Bachelor's degree in Communication Studies with a minor in Economics at Northeastern University in Boston, USA (2013-2018), graduating cum laude. During her undergraduate studies, she spent a semester at the University of Amsterdam, the Netherlands, where her interest in health communication deepened. Sara gained hands-on experience in the field of health communication through roles at the ALS Therapy Development Institute (a nonprofit biotech focused on ALS research), Aria Marketing (a strategic healthcare communications agency), and PAN Communications (an integrated marketing and public relations firm specializing in health tech and life sciences).

In 2019, she began the Research Master in Communication Science at the University of Amsterdam, which she completed cum laude in 2021. Her Master's thesis was awarded Top Student Abstract and Presentation at the *European Conference on Health Communication* in 2021, recognizing its contribution to the field. Alongside her studies, she worked as a research assistant at the Amsterdam Center for Health Communication and the Internal Medicine Department (Section of Geriatrics) at Amsterdam UMC.
Sara pursued her PhD at the Amsterdam School of Communication Research (ASCoR), in close collaboration with the Section of Geriatrics at Amsterdam UMC, location University of Amsterdam, and the Dutch National Expert Center on Injury Prevention (VeiligheidNL). Her four-year project was self-initiated with the guidance of her supervisors and supported through grant applications.

Beyond her research, Sara supervised undergraduate students in the Medical Science program and contributed to policy translation by advising the Dutch Ministry of Health, Welfare, and Sport (VWS) on the national implementation of the Valanalyse 2.0. She also served on several advisory committees during her PhD, including the National Falls Prevention Program Plan. In 2023, she received a travel grant to conduct a two-month research visit at the University of Sydney, Australia, where she collaborated with leading experts in falls prevention and health literacy.

Sara currently continues her research as a Postdoctoral Research Fellow at the Department of Public and Occupational Health at Amsterdam UMC, location Vrije Universiteit Amsterdam.