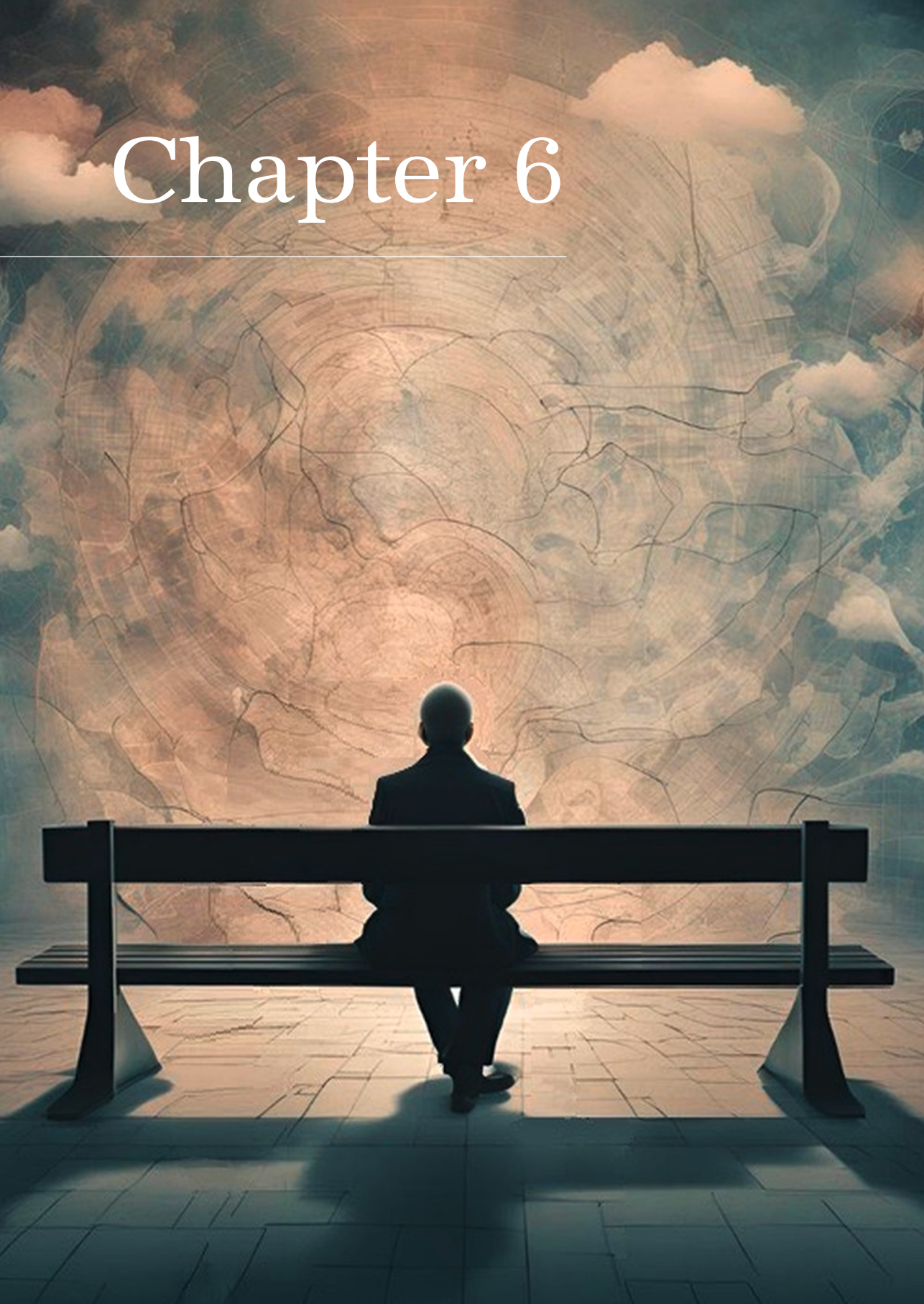
Navigating the future with chronic kidney disease: towards patient-centred prognostic modelling

Milders, J.

Chapter 6



SUMMARY AND GENERAL DISCUSSION

Summary and general discussion

This thesis set out to improve patient-centred prognostic information provision in nephrological patient care. Using a combination of quantitative and qualitative research methods, we explored CKD patients' perspectives regarding their future, the prognostic topics they prioritise, and which prognostic questions they have. Furthermore, in a scoping review, we mapped out the current field of prognostic modelling in nephrology, identifying key knowledge gaps and ways to potentially bridge the gap between prognostic research and the implementation of prognostic models in clinical practice. Finally, we evaluated the role of patient-reported outcomes (PROs) as predictors of mortality in dialysis patients, demonstrating their potential in improving nephrological prognostic models. In this final chapter, we summarize the main findings of the research included in this thesis. Additionally, we discuss the clinical implications of our work, and provide directions for future research on prognostic information provision and patient-centred prognostic modelling in nephrology.

Summary of main findings

Prognostic information provision in nephrological care

In **Chapter 2**, we conducted a survey study among 163 CKD patients to explore whether they want to know more about their future, and if so, which prognostic topics are of interest to them. We found that most patients with CKD think about their future on a regular basis, and they showed interest in receiving more prognostic information from their healthcare providers. However, despite this wish for more prognostic information, a large portion of patients did not yet discuss the future with their nephrologist, revealing a gap in current prognostic communication. Notably, patients without kidney replacement therapy (KRT) reported thinking about and discussing their future more frequently than those receiving dialysis treatment or those who received a kidney transplant. Women also reported thinking about their future more than their male counterparts. However, despite thinking about the future more frequently, women discussed it with their healthcare providers less often. We did not find any notable differences based on age. The vast majority of patients reported wanting to know more about their prognosis, regardless of whether it was positive or negative information. Prognostic outcomes that were prioritized by patients included laboratory values, symptoms, and physical well-being. However, different priorities were observed between patients from different CKD stages (CKD, dialysis and kidney transplantation). For instance, dialysis patients prioritized mental well-being instead of physical well-being.

Following our findings from Chapter 2, **Chapter 3** presents a qualitative analysis of the open-ended survey responses. We aimed to explore two key research questions: 1) How do patients with CKD view their future? and 2) What are the prognostic questions of patients regarding their future with CKD?. We found that patients with CKD experience a broad variety of emotions when thinking about their future, ranging from negative emotions such as uncertainty, fear, sadness and anger, to more positive emotional responses like calmness, hope and trust.

Moreover, some patients experienced a mix of both positive and negative emotions, while others described experiencing a form of emotional neutrality. For these patients, thoughts about the future with CKD did not evoke any particularly negative or positive emotions. Beyond the diverse emotional responses, patients described a wide array of prognostic questions that they had, concerning topics like treatment of CKD, kidney disease progression, self-management, symptoms, life expectancy and life participation. Although the majority of patients desired more personalized prognostic information on these topics, some patients expressed no need for additional information about their future. These patients either felt sufficiently informed about their prognosis by their healthcare providers or had sought out relevant information themselves. Others preferred to focus on the present.

Prognostic modelling in nephrology

Chapter 4 presented a scoping review providing a comprehensive overview of all studies developing, validating, or updating a prognostic model for patients with CKD, including those receiving kidney replacement therapy. We made inventory of the outcomes that were predicted, the methodological quality of existing models, and any validation or updating efforts. In total, 602 studies were included, of which 181 (30.1%) concerned a CKD population, 190 (31.6%) a dialysis population and 231 (38.4%) a kidney transplantation population. In 415 studies a novel prognostic model was developed, in 205 an existing model was externally validated and in 62 a model was updated. We found that the most frequently predicted outcomes were mortality (*n*=192), kidney disease progression (*n*=75), and kidney graft survival (*n*=54). For a variety of clinically important outcomes, including disease progression, cardiovascular events, mortality and graft survival, several robust and well-validated models existed. However, prognostic models for PROs, such as health-related quality of life or social participation, were scarce or even non-existing. Methodological concerns were also present in most studies. Often, sample sizes were small, reporting guidelines were not adhered to and no or inappropriate performance measures were presented. Specifically, discrimination of the prognostic model was usually presented (80.4%) but measures of calibration were shown in less than half of the studies (43.4%). In addition, the majority of prognostic models were not presented in a useable format (e.g. a full regression formula or risk score), making validation or implementation impossible. There was a lack of validation and updating efforts: of the 415 development studies that were included, 28.0% did not perform any validation of the model (internal or external), and 57.6% performed only internal validation. Only 111 models (26.7%) were externally validated, either within the development study itself, or in an independent external validation study. A notable finding was that patients from Africa, South America and Australia were severely underrepresented in prognostic studies, questioning the applicability of models in these patient populations.

While PROs have demonstrated predictive potential in other medical fields, their use in prognostic modelling within nephrology remains limited. Therefore, in **Chapter 5**, we examined the added predictive value of PROs in the prediction of two-year mortality among incident dialysis patients. Using data from the NECOSAD and EQUAL cohorts, as well as a subset of NECOSAD including only patients aged 65 years and older, we first developed a base prognostic model consisting of traditional clinical predictors (i.e. demographics, comorbidities and laboratory measurements). We then extended this base model using the following PROs: the mental component score, physical component score, general health perception, depressive symptoms, number of symptoms, symptom burden, fatigue and pain. Our findings demonstrate that the inclusion of PROs in prognostic models for mortality significantly improve their predictive accuracy. The base model already performed well and yielded optimism-corrected area-under-the-curves (AUCs of 0.806, 0.781 and 0.699. After addition of the PROS, the AUCs improved to 0.826, 0.878 and 0.746. Additionally, measures of calibration, Brier scores, likelihood ratio tests, reclassification tables, net reclassification indices (NRI), the integrated discrimination improvements (IDI) and decision curve analyses consistently confirmed the added predictive value of PROs throughout all cohorts. When comparing different predictor groups (e.g. demographics, laboratory measurements or PROs), PROs consistently outperformed the demographic predictors age and sex, and the laboratory measurements (haemoglobin, systolic blood pressure, serum albumin and residual glomerular filtration rate [rGFR]). Notably, the group of PROs alone demonstrated a moderate ability to predict mortality. When assessing the performance of each individual PRO, the summarizing variables (mental and physical component score, general health perception, depressive symptoms, symptom burden and symptom number) outperformed the individual symptoms pain and fatigue. Across all cohorts, the mental and physical component score, and symptom burden had the most consistent strong predictive performance.

Altogether, the studies in this thesis underline a clear discrepancy between the prognostic information that patients seek and what is currently provided. Patients express an explicit desire for more information about the future, but are often left with unmet informational needs. They prioritize a wide range of prognostic topics, including symptoms, quality of life, and mental and physical well-being. Yet, these topics are often overlooked in favour of traditional clinical endpoints like disease progression and mortality. Furthermore, while prognostic models have the potential to support individualized prognostic information provision, most existing models fail to capture the outcomes that matter most to patient. In addition, their implementation in clinical practice is hindered by several barriers, including methodological concerns, insufficient validation and updating, and lack of impact assessment.

General discussion

The findings of this thesis provide valuable insights into the current state of prognostic communication and the use of prognostic models in nephrology. While the specific limitations, considerations and implications of each study are discussed in detail in the corresponding chapters (Chapter 2-5), this section takes a broader perspective. Here, we discuss the overall implications of our research on clinical practice, and highlight key directions for future research. Additionally, we propose potential strategies to improve prognostic information provision and the integration of patient-centred prognostic models in nephrological patient care.

Implications for clinical practice

IMPROVING PROGNOSTIC INFORMATION PROVISION FOR KIDNEY PATIENTS

The findings of our survey reveal that there is a significant discrepancy between patients' wishes for prognostic information and the information that is currently provided by healthcare providers. While discussions about the future do take place, they seem to be lacking in detail and personalization, leaving many patients with informational needs that are unmet. Ultimately, our findings underline the need for a more personalized and patient-centred approach to prognostic information provision in nephrology. Importantly, prognostic information provision cannot be one-size-fits-all, and discussions about the future need to be tailored to the individual patient, taking into account their unique needs and preferences. To bridge this gap between patients' wishes and the current level of prognostic communication, healthcare providers should actively explore each individual's preferences regarding prognostic discussions, as these preferences differ not only based on factors like gender, age and disease stage but also on more personal characteristics, such as someone's coping style, outlook on life and attitude towards uncertainty and risks. For example, kidney transplant recipients may prioritize information on outcomes related to their kidney graft (e.g. graft survival), whereas dialysis patients may focus on topics like energy levels and health-related quality of life. Additionally, women report thinking about their future with CKD more frequently than men but discuss it with their healthcare providers less often, suggesting possible gender-based differences in informational needs. Furthermore, while some patients would like to know as much as possible about their future with CKD, others prefer to live in the present moment. Therefore, to ensure that prognostic information empowers rather than overwhelms them, it is essential to determine how much that individual actually wants to know. Acknowledging all these nuances, and tailoring prognostic communication strategies accordingly, allows for more relevant and individualized conversations about prognosis. However, understanding and recognizing the individuality of prognostic questions that patients have is only the first step. Clinicians have several strategies at hand to further improve and individualize prognostic information provision.

Proactively engaging in open discussions about patient preferences

Potentially the most effective way to explore patient preferences is by routinely asking them what they want to know, how much they want to know, when they want to know it, and how they prefer to receive prognostic information. Expressing these preferences, however, may not always be easy for patients, as they may be unsure about what they actually want to know. Through holding open, and ongoing discussions about patients' prognostic questions and preferences, healthcare providers can better understand what that individual needs from them, and how to adapt their communications strategies accordingly.

Training on effective risk communication

Clear and effective communication of expected prognosis is challenging, especially when the information is uncertain or involves distressing information for patients. While some research has been performed on how to convey risk estimates, specific guidance on how to do this in clinical practice is lacking. (1) Therefore, training programs for healthcare providers should be created that focus on how to communicate prognostic information, including advice on how to discuss uncertainty, address emotional responses, and convey information in an understandable manner.

The use of tools to convey prognostic information

Several tools can support healthcare providers in conveying complex prognostic information in a clear and accessible manner. For instance, decision aids, mobile apps, and patient dashboards containing disease-specific information, can be valuable additions to their clinical expertise. (2) These tools allow patients to explore information on, for example, expected disease progression and treatment outcomes, estimated survival, and other relevant outcomes at their own pace. Furthermore, these tools can contain clear visual representations of prognostic information. Importantly, these tools differ from prognostic models in that they serve as communication aids rather than generating individualized risk predictions. However, such tools also exist to communicate risks calculated by a prognostic model. For example, the website of the Kidney Failure Risk Equation (KFRE) is an interactive platform that helps patients and healthcare providers interpret risk estimates generated by the KFRE in a more accessible way. (3)

The use of prognostic models to provide individualized prognoses

Prognostic models are powerful tools to give patients and healthcare providers more individualized information on the future. However, despite this potential, models are currently underutilized in nephrology. Previous research has shown that patients are interested in discussing predicted risks of outcomes like mortality, disease progression and cardiovascular events, as these predictions could act as motivators for self-management, aid them in planning for their future, provide them with relevant disease-specific information earlier on, and possibly comfort them. (4, 5) Well-validated and impactful models should be integrated into routine consultations and patient information systems to enhance conversations about the future.

IMPLEMENTATION OPPORTUNITIES FOR PROGNOSTIC MODELS IN NEPHROLOGY

Prognostic models have great potential to improve prognostic information provision for kidney patients. The prognostic information obtained through models can support patients in navigating the uncertainties surrounding a future with CKD, as it helps them and their healthcare providers better understand the expected disease trajectory. Furthermore, prognostic models can complement clinical expertise by providing more individualized and accurate risk predictions based on a broad range of patient characteristics. Additionally, prognostic models play an important role in healthcare planning by guiding referrals to nephrologists, planning vascular access for kidney replacement therapy, and supporting kidney allocation decisions. Although a plethora of models exist and are continuously being developed, their clinical uptake remains limited. In this thesis, we uncovered key strategies and opportunities to improve the clinical uptake of prognostic models in nephrology.

Focus on methodology and reporting of prognostic studies

The methodological and reporting quality of current prognostic studies is often subpar, and relevant guidelines like the Individual Prognosis Or Diagnosis guideline (TRIPOD), are often not used. (6, 7) For instance, in our scoping review, only about 14% of the studies published after the release of the TRIPOD statement in 2015, referenced the guideline. To increase chances of implementation of a model, it is important that researchers focus on rigorous methodology and reporting. To do so, adherence to the TRIPOD is recommended as it provides authors with a structured framework for transparent and comprehensive reporting of their development and validation studies. Furthermore, adequate sample size calculations should be performed to prevent overfitting of the model, all relevant performance measures (e.g. measures of discrimination and calibration) should be reported, a usable format of the model should be presented (e.g. a complete formula or risk score), and measures to take into account algorithmic bias should be considered. (8-10) Rather than developing models for the sake of publishing, researchers should prioritize the clinical applicability by ensuring robustness of their models.

Prioritizing external validation and updating over model development

Instead of the continuous development of novel prognostic models, future research should focus on validating and updating promising existing models. External validation is an essential step in taking a prognostic model from its development to being used in patient care, as it determines a model's ability to predict the outcome in a new and different set of patients beyond the development cohort. (11, 12) To ensure that the model is reliable, useful and accurate in the population that it is intended to be used in, targeted validation is crucial. (12, 13) In addition, updating existing models—rather than continuously developing new ones—helps combat research waste and maximizes the use of prior knowledge while improving performance in the target population. Currently, only a small fraction of models is ever externally validated, and if validated, the validation studies are often poorly conducted and reported. (14) Recently, comprehensive comparative external validation studies have emerged, in which the performance of multiple prognostic models predicting the same outcome is compared. (15-17) Beyond assessing the generalizability of these models through

external validation, these studies help healthcare to directly determine which model performs best for a given outcome. These studies also allow us to see whether a novel model performs better than an already implemented model, making it possible to determine whether implementation of this new model is worth considering and investing in.

Assess clinical impact of prognostic models

After successful development, validation and, if necessary, updating of a prognostic model, assessment of its clinical implementation and impact should be a priority. Implementation studies are essential to better understand the barriers and facilitators to model uptake in clinical practice. In addition, a well-performing model does not always directly translate into a clinically useful model, and impact studies are needed to assess how a model influences for example patient outcomes and satisfaction, clinical decision-making, and the allocation of healthcare resources. (12, 18) Ideally, impact of a prognostic model is assessed in randomized controlled trial. However, observational alternatives to these so-called impact trials exist. (18) Currently, implementation and impact studies for nephrological models are scarce, limiting their potential uptake.

Address barriers to the use of models experienced by healthcare providers

An important barrier to the implementation of prognostic models stems from the healthcare providers who are intended to use them. Previous research has shown that nearly half of the nephrologists do not use prognostic models. (5) They reasoned that models were not reliable enough, were hard to find, complicated to use, and take up too much time. Furthermore, they were worried that predictions from prognostic models could give patients false expectations. (5) To address these concerns, efforts should be made to better integrate prognostic models into clinical workflows. This could be achieved by endorsing the use of models in clinical guidelines to increase trust among clinicians or by embedding models into electronic health record systems to enhance accessibility. Additionally, providing training on the use of models and ensuring that models are user-friendly could further enhance clinicians' confidence in using them.

Exploring the potential of counterfactual prediction

An emerging yet still largely unchartered concept is counterfactual prediction, which combines elements of causal inference and predictive modelling. Counterfactual prediction uses data to estimate how an outcome would change under different hypothetical conditions. (19) In a clinical setting, counterfactual prediction holds great potential as it would allow prediction of potential outcomes under different treatment strategies, such as dialysis versus conservative management. (20) This approach could support more personalized and informed shared decision-making for patients and healthcare providers. However, despite its potential and clinical relevance, counterfactual prediction poses methodological complexities. An important issue is that we cannot observe the outcome for an individual under all possible hypothetical scenarios. In addition, confounding and ensuring reliable estimates are key concerns, limiting the current implementation of

counterfactual prediction. As this field continues to develop, addressing these challenges will be important to integrate counterfactual prediction as a valuable tool in nephrological patient care.

Moving towards patient-centred prognostic modelling

Over the past years, a large shift towards more patient-centred care has taken place in nephrology. (21) Instead of focusing solely on clinical traditional outcomes, PROs are rapidly gaining recognition, and patients play a more important role in their own disease management and treatment trajectory. However, this shift is currently not yet reflected in prognostic research and model development. (22) Traditionally, prognostic research in nephrology prioritizes clinical outcomes like mortality, kidney disease progression and graft survival, and models predicting PROs—such as quality of life and symptom burden—are rare or even non-existent. Moving forward, it is crucial to incorporate PROs as key outcomes in prognostic research, ensuring that models reflect the needs and preferences of kidney patients in terms of prognostic information. By embracing a patient-centred approach to prognostic modelling, prognostic models can become more meaningful, usable and better aligned with what actually matters to those the models and the information they provide are meant for: the patients themselves.

Using patient-reported outcomes (PROs) to enhance prognostic models

In addition to broadening the scope of predicted outcomes, prognostic models should also include PROs as predictors more often. (22) Studies from other medical fields (e.g. oncology), and the findings of our study presented in Chapter 5 of this thesis suggest that PROs hold predictive power and could enhance the accuracy of prognostic models significantly. (23, 24) Evidently, patients have an intuitive understanding of their current health status, and self-reported measures like symptom burden or mental health scores can accurately predict outcomes, even without clinical measures. A simple question about how the patient is doing may offer quick, yet meaningful, insights into the prognosis of that individual. Moreover, PROs may be easier to collect than certain predictors that are often used, such as laboratory measurements. This simplicity potentially enhances the usability of prognostic models, which is currently an important barrier to their implementation.

Directions for future research

Several important aspects of patients' prognostic informational needs and how to meet these remain unexplored, and further research is needed. First, it would be valuable to conduct research on the preferred timeframes for prognostic information. For example, short-term prognostic information may be more actionable and more relevant for clinical decision-making, whereas long-term prognostic information can help patients gain a better understanding of their future disease trajectory. Second, more qualitative research—such as interviews and focus group studies—should be conducted to delve further into the prognostic preferences and needs of patients with CKD. These types of studies allow for a more in-depth exploration of topics concerning patients' feelings, values, reasoning and

stories. Third, in future research, the potential of digital tools like patient dashboards and decision aids should be evaluated. Such tools could improve accessibility and personalization of prognostic information for kidney patients. Fourth, the relationships between patients' emotional responses and coping strategies, and their prognostic information needs should be further investigated. Exploring how emotional responses influence *what* patients want to know, and *when* they want to know it, could provide healthcare providers with guidance on how to tailor prognostic communication to the individual in front of them. Finally, future research should address the barriers that healthcare providers experience in implementing prognostic models. Better understanding their concerns about model usability, reliability and risk communication could help identify solutions.

For future prognostic modelling research, we recommend that researchers focus on several important aspects. For example, more studies should be conducted in populations that are currently underrepresented in prognostic research, such as patients receiving conservative management, and patients from continents like Africa and South America. These patient groups are usually not included in prognostic studies, limiting the applicability of prognostic models to these patients. Additionally, as mentioned before, researchers should ensure rigorous methodology and reporting, and external validation and impact studies should be prioritized over the continuous development of novel models. Furthermore, counterfactual prediction presents great potential to support informed shared decision-making, and future studies should explore the possibilities of this concept in nephrology while addressing the accompanying methodological challenges. Another important area for future research is the communication of risks derived from prognostic models, as patients may struggle to interpret these predictions and their uncertainties. Discovering ways to present these predicted risks in an understandable and meaningful way is essential for patient-centred care. Finally, the patient perspective should be considered in prognostic research, both when choosing the outcomes to predict and the predictors included in the model.

Conclusions

In this thesis, we set out to improve patient-centred prognostic information provision in nephrology by exploring CKD patients' perspectives about the future, their prognostic informational needs and the potential role of prognostic models. The findings of our research reveal that, although many patients seek more individualized insights into their future with CKD, discussions about prognosis are currently insufficient, leaving patients with unanswered prognostic questions. Our work highlights the importance of a more individualized approach to prognostic communication, taking into account the unique needs and preferences of each individual. Prognostic models hold great potential to improve and personalize prognostic information provision, however, despite a major upsurge in prognostic research in nephrology, the uptake of these models in patient care remains limited. In this thesis, we map out the current state of prognostic research, and outline key barriers and opportunities for their implementation. A key recommendation emerging from our work is to ensure that prognostic models reflect what truly matters to patients by incorporating PROs as outcomes. Additionally, given their demonstrated added predictive value, PROs should also be considered more frequently as predictors in prognostic models to improve model accuracy. Ultimately, by bridging the gap between the prognostic information patients seek and what is currently provided, and by refining prognostic models to better align with patient priorities, we take an important step toward more patient-centred nephrological patient care. In doing so, we can better support patients in navigating their future with CKD and the uncertainties that come with it.

References

1. University of Cambridge. Winton Centre for Risk and Evidence Communication. [Available from: https://wintoncentre.maths.cam.ac.uk/resources/medicine/.
2. Engels N, van der Nat PB, Ankersmid JW, Prick JCM, Parent E, The R, et al. Development of an online patient decision aid for kidney failure treatment modality decisions. BMC Nephrol. 2022;23(1):236.
3. The Kidney Failure Risk Equation https://kidneyfailurerisk.com/.
4. de Jong Y, van der Willik EM, Milders J, Meuleman Y, Morton RL, Dekker FW, et al. Person centred care provision and care planning in chronic kidney disease: which outcomes matter? A systematic review and thematic synthesis of qualitative studies : Care planning in CKD: which outcomes matter? BMC Nephrol. 2021;22(1):309.
5. van der Horst DEM, Engels N, Hendrikx J, van den Dorpel MA, Pieterse AH, Stiggelbout AM, et al. Predicting outcomes in chronic kidney disease: needs and preferences of patients and nephrologists. BMC Nephrol. 2023;24(1):66.
6. Collins GS, Reitsma JB, Altman DG, Moons KG. Transparent reporting of a multivariable prediction model for individual prognosis or diagnosis (TRIPOD): the TRIPOD Statement. BMC Med. 2015;13:1.
7. Moons KG, Altman DG, Reitsma JB, Ioannidis JP, Macaskill P, Steyerberg EW, et al. Transparent Reporting of a multivariable prediction model for Individual Prognosis or Diagnosis (TRIPOD): explanation and elaboration. Ann Intern Med. 2015;162(1):W1-73.
8. Riley RD, Snell KIE, Ensor J, Burke DL, Harrell FE, Jr., Moons KGM, et al. Minimum sample size for developing a multivariable prediction model: Part I - Continuous outcomes. Stat Med. 2019;38(7):1262-75.
9. Riley RD, Snell KI, Ensor J, Burke DL, Harrell FE, Jr., Moons KG, et al. Minimum sample size for developing a multivariable prediction model: PART II - binary and time-to-event outcomes. Stat Med. 2019;38(7):1276-96.
10. Riley RD, Ensor J, Snell KIE, Harrell FE, Jr., Martin GP, Reitsma JB, et al. Calculating the sample size required for developing a clinical prediction model. BMJ. 2020;368:m441.
11. Ramspek CL, Jager KJ, Dekker FW, Zoccali C, van Diepen M. External validation of prognostic models: what, why, how, when and where? Clin Kidney J. 2021;14(1):49-58.
12. Moons KG, Kengne AP, Grobbee DE, Royston P, Vergouwe Y, Altman DG, et al. Risk prediction models: II. External validation, model updating, and impact assessment. Heart. 2012;98(9):691-8.
13. Sperrin M, Riley RD, Collins GS, Martin GP. Targeted validation: validating clinical prediction models in their intended population and setting. Diagn Progn Res. 2022;6(1):24.
14. Collins GS, de Groot JA, Dutton S, Omar O, Shanyinde M, Tajar A, et al. External validation of multivariable prediction models: a systematic review of methodological conduct and reporting. BMC Med Res Methodol. 2014;14:40.
15. Ramspek CL, Evans M, Wanner C, Drechsler C, Chesnaye NC, Szymczak M, et al. Kidney Failure Prediction Models: A Comprehensive External Validation Study in Patients with Advanced CKD. J Am Soc Nephrol. 2021;32(5):1174-86.
16. Ramspek CL, Voskamp PW, van Ittersum FJ, Krediet RT, Dekker FW, van Diepen M. Prediction models for the mortality risk in chronic dialysis patients: a systematic review and independent external validation study. Clin Epidemiol. 2017;9:451-64.
17. van Rijn MHC, van de Luijtgaarden M, van Zuilen AD, Blankestijn PJ, Wetzels JFM, Debray TPA, et al. Prognostic models for chronic kidney disease: a systematic review and external validation. Nephrol Dial Transplant. 2021;36(10):1837-50.
18. Janse RJ, Stel VS, Jager KJ, Tripepi G, Zoccali C, Dekker FW, et al. When impact trials are not feasible: alternatives to study the impact of prediction models on clinical practice. Nephrol Dial Transplant. 2024;40(1):27-33.

19. Dickerman BA, Hernan MA. Counterfactual prediction is not only for causal inference. Eur J Epidemiol. 2020;35(7):615-7.
20. Ramspek CL, Verberne WR, van Buren M, Dekker FW, Bos WJW, van Diepen M. Predicting mortality risk on dialysis and conservative care: development and internal validation of a prediction tool for older patients with advanced chronic kidney disease. Clin Kidney J. 2021;14(1):189-96.
21. O'Hare AM. Patient-Centered Care in Renal Medicine: Five Strategies to Meet the Challenge. Am J Kidney Dis. 2018;71(5):732-6.
22. Couchoud C, Hemmelgarn B, Kotanko P, Germain MJ, Moranne O, Davison SN. Supportive Care: Time to Change Our Prognostic Tools and Their Use in CKD. Clin J Am Soc Nephrol. 2016;11(10):1892-901.
23. Jang KS, Jeon GS. [Prediction Model for Health-Related Quality of Life in Hospitalized Patients with Pulmonary Tuberculosis]. J Korean Acad Nurs. 2017;47(1):60-70.
24. Lee SK, Son YJ, Kim J, Kim HG, Lee JI, Kang BY, et al. Prediction Model for Health-Related Quality of Life of Elderly with Chronic Diseases using Machine Learning Techniques. Healthc Inform Res. 2014;20(2):125-34.