MANagement Of patients with Systemic Sclerosis (MANOSS project):

A mixed methods study of chronic illness management practice patterns and the development of a new model of care

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Agnes Magdalena Kocher
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On application of

Supervisor:	Prof. Dr. Dunja Nicca
Co-Supervisor:	Prof. Dr. Michael Simon
Further expert:	Prof. Dr. med. Peter M. Villiger
Further expert:	Prof. Dr. Andrew A. Dwyer
External expert:	Prof. Dr. Janet Poole (External expert)

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List of Abbreviations

CBDS	Computer-based decision support systems
CCM	Chronic Care Model
CFL	Complete feedback loop
CIM	Chronic Illness Management
COI	Cost of illness
CTD	Connective tissue diseases
eCCM	eHealth Enhanced Chronic Care Model
EHR	Electronic Health Records
EULAR	European Alliance of Associations for Rheumatology
EURORDIS	Rare Diseases Europe
EUSTAR	European Scleroderma Trials And Research
EQ-5D	European Quality of Life 5 Dimensions
HADS	Hospital Anxiety and Depression Scale
HAQ	Health Assessment Questionnaire
HPs	Healthcare professionals
HRQoL	Health-related quality of life
HSCT	Haematopoietic stem cell transplantation
ICT	Internet-based information and communication technologies
IT	Information technology
LOS	Length of stay
MCS	Mental health component score (SF-36)
PCS	Physical health component score (SF-36)
PHR	Personal Health Records
PREMs	Patient-reported experience measures
PROMIS	Patient-Reported Outcomes Measurement System
PROMIS-29	Patient-Reported Outcomes Measurement Information System-29 questionnaire
PROMs	Patient-reported outcome measures
RCTs	Randomized controlled trials
ScleroID	Systemic Sclerosis Impact of Disease questionnaire
SD	Standard deviation

SDM	Shared decision making
SF-36	Short Form 36 questionnaire
SHAQ	Scleroderma Health Assessment Questionnaire
SLE	Systemic lupus erythematosus
SPIN	Scleroderma Patient-centered Intervention Network
SSc	Systemic sclerosis
SSc-ILD	Systemic sclerosis interstitial lung disease
SScQoL	Systemic Sclerosis Quality of Life questionnaire
TOSS	Taking Charge of Scleroderma
WHO	World Health Organization

Summary

Systemic sclerosis (SSc) is a rare multisystemic autoimmune connective-tissue disease characterized by a chronic and frequently progressive disease course. Approximately 20 in 100'000 adults are affected.[1, 2] Variability in disease severity, progression, and organ involvement challenge timely diagnosis and effective disease management, contributing to high mortality.[1, 3] Approximately 75% of patients develop organ involvement within the first five years of diagnosis, with early manifestations including skin fibrosis (75%), gastrointestinal symptoms (71%), lung involvement (65%), digital ulcers (34%) and cardiac involvement (32%).[3]

For patients with rapidly progressive dcSSc and a high risk of organ failure in an early disease stage the only treatment known to modify the overall disease course is autologous haematopoietic stem cell transplantation (HSCT).[4, 5] However, HSCT therapy's high mortality rates and association with secondary autoimmune diseases make it only recommendable for patients with early rapidly progressive SSc, yet without severe organ involvement.[5] In most cases, then, medical management must be tailored to individual organ sequelae and disease progression, i.e., regular multidisciplinary consultations to identify organ involvement early as well as pharmacological and non-pharmacological interventions to decrease/slow disease progression and reduce organ damage.[4]

At the same time, therapeutic interventions need to focus on improving the SSc population's health-related quality of life (HRQoL).[6] Over the disease's trajectory, patients experience numerous physical and psychosocial problems, including fatigue, hand stiffness, Raynaud's phenomenon, digital ulcers, shortness of breath, pain, gastrointestinal symptoms, work disability, depression, anxiety (e.g., regarding disease progression), and dissatisfaction with body image.[6-10] Numerous studies report severely impaired physical and psychological HRQoL in SSc.[10-13]

Rare disease patients' disease pathways are often complex, calling for large numbers of healthcare professionals (HPs), all of whom need to collaborate and coordinate their efforts to deliver safe, effective high-quality care.[14, 15] Compared to groups with more frequent chronic diseases, SSc patients are less likely to receive timely, person-centred care tailored to their individual health problems and psychosocial concerns. And as most interventions for patients with rare diseases are only available at specialized treatment centres, distance from a centre can act as a further barrier.[14, 16]

To ease the strain SSc patients face to receive high-quality treatment, it will be necessary to optimize and reshape the current SSc management system. To guide this process, we will use the eHealth-enhanced chronic care model (eCCM), a longstanding and widely adopted development model that includes eHealth approaches to guide chronic illness management.[17-19] Its central aim is to improve health outcomes through effective and productive interactions between prepared, proactive practice teams and informed, activated patients.

The eCCM defines and focuses on seven core elements of effective healthcare delivery: community resources, health system factors, self-management support, delivery-system design (e.g., continuity of care), decision support, clinical information systems, and eHealth education.[18] A significant body of literature has reported that in highly prevalent chronic conditions such as asthma, cardiovascular disease, depression, diabetes and osteoarthritis, incorporating eCCM elements (e.g., self-management support, clinical decision support) into care is associated with improvements in patient health outcomes, reduced health service use and reduce healthcare costs.[19-22]

Unlike with frequent chronic conditions, however, few examples describe the development and evaluation of integrated care models for rare diseases.[23-26] Similarly, participatively developed (i.e., by patients and providers together) care models for SSc with appropriate contextually adapted strategies are scarce.[27]

Therefore, for patients living with SSc in Switzerland and their families, the MANagement Of Systemic Sclerosis (*MANOSS*) study aims to develop a rare disease chronic care model based on a contextual analysis and stakeholder involvement. When empirical evidence is limited (as is often the case with rare disease populations), an in-depth understanding of context, practice patterns and the target audience's needs and barriers is crucial.[28-31] Before beginning our development process, compelling arguments support the need to first describe and understand the practice patterns and needs of the target patient group (in this case, people living with SSc), as well as the perspectives of the HPs who care for them within the Swiss healthcare system.

Therefore, this dissertation's main objective is to generate a comprehensive understanding of current chronic illness management and eHealth use in SSc. Our findings will inform the development of a chronic care model that focuses entirely on rare disease management. Preliminary steps included the adaptation and validation of specific measurement tools for the SSc population, followed by two mixed-method studies to assess chronic care and eHealth implementation in the Swiss setting in consultation with all relevant stakeholder groups.

Chapter 1 provides a general introduction to current situation regarding medical and non-pharmacological SSc management. This chapter also presents the *MANOSS* project's theoretical framework, including the evidence base regarding eHealth-facilitated integrated care models first for more common chronic diseases, then those specifically for rare rheumatic conditions. In addition, it summarizes selected approaches to assessing eHealth-facilitated integrated care in SSc.

Chapter 2 presents this dissertation's rationale and specific study aims.

The study protocol presented in **Chapter 3** describes the contextual analysis and development of a culturally sensitive chronic illness management model for patients with SSc and their families (i.e., the *MANOSS* study protocol*)*. This includes a description of the explanatory sequential mixed method study we conducted for our contextual analysis, which was supported by broad stakeholder involvement regarding the model's development, plus a Delphi study to reach consensus. As our guiding framework, we chose the eCCM.[17, 18]

To the best of our knowledge, *MANOSS* is the first study to assess chronic illness management and technology readiness in a rare rheumatic disease such as SSc from the perspectives of patients, families and HPs. Concretely, this study consists of three phases, the first two of which we have completed. First, to identify SSc patients' and HPs' current chronic illness management practice patterns and technology readiness, we conducted a quantitative cross-sectional survey of patients and healthcare professionals. Second, to deepen our understanding of the care needs identified via the quantitative survey, we conducted qualitative interviews with patients (n=14), family members (n=5) and HPs (n=14). Participants of both study phases were recruited from all Swiss University hospitals (Basel, Bern, Geneva, Lausanne, Zurich), one regional (state) hospital (Lucerne), rheumatology outpatient clinics and the Swiss scleroderma patients' association.

For the third phase, based on our analyses of the survey and interview data from the earlier phases, plus input from patients, healthcare professionals, and other experts, we will co-create a model of integrated SSc care. As a first step, to discuss and validate our quantitative and qualitative findings, we conducted three national/international focus group discussions (n=17) with individuals with several years of experience with

(1) SSc as a patient or (2) family member and/or (3) professional experience in chronic care, implementation science, and/or health policy. Last (not part of this dissertation), we will incorporate the overall findings of the MANOSS project into the first draft of a logic model, which will describe how we anticipate our proposed integrated care activities and implementation strategies will lead to the desired outcomes.[32]

Chapter 4 describes our revision and validation of the German version of the 29-item Systemic Sclerosis Quality of Life Questionnaire (SScQoL). The SScQoL is a rare disease patient-reported outcome measure (PROM) validated in six languages to assess health-related quality of life (HRQoL) in SSc.[33, 34] Previous evaluation of the German version revealed problems with dichotomous responses.[33] Our study's aim was to revise the German SScQoL by extending its response structure, as well as re-evaluating its content and construct validity, reliability and unidimensionality. For example, based on our cognitive debriefing of patients (n=6) we extended dichotomous items to a 4-point response structure.[35, 36]

A total of 78 patients completed the revised SScQoL. Rasch analysis was employed to test its validity, reliability and unidimensionality.[37, 38] Initial results for the 29 items suggested the scale lacked fit with the model (χ^2=51.224, df=29, p=0.007). Grouping the items into five domains resulted in an adequate fit (χ^2=5.343, df=5, p=0.376) and unidimensionality (proportion of significant independent t-tests: 0.045, 95%CI: 0.016 to 0.114). The results indicate that, with its 4-point response structure, the revised German SScQoL is a valid and reliable measure. Further analyses suggested that the scale was well targeted, had high internal consistency (Person Separation Index, PSI=0.931) and worked consistently in patients with different demographic and clinical characteristics.

The manuscript presented in **Chapter 5** reports on our explanatory sequential mixed methods analysis[39] of the current state of SSc chronic illness care from the patients' perspective, along with their HRQoL. For the first of these, our quantitative phase collected patients' (n=101) ratings of the chronic care they received across the five dimensions of the Patient Assessment of Chronic Illness Care (PACIC) scale;[40] for the second it used the SScQol.[33] The results informed the subsequent qualitative phase, which involved interviews with (n=4) individuals and one focus group (n=4).

For this phase, our main aim was to use both the interview and focus-group data to clarify the larger group's PACIC responses. The mean overall PACIC score was 3.0 out of a maximum score of 5 (95% CI: 2.8–3.2, n= 100), indicating that SSc care was 'never' to 'generally not' aligned with the CCM. Overall, the chronic care ratings were relatively poor. In fact, certain key elements of chronic care (i.e., shared decision-making and self-management support) were notably absent from several patients' SSc management.

The quantitative findings were congruent with our qualitative data: patients confirmed frequently encountering major shortcomings in care. These included *experiencing organized care with limited participation*, *not knowing which strategies are effective or harmful* and *feeling left alone with disease and psychosocial consequences*. They filled these gaps in care by *dealing with the illness in tailored measure*, *taking over complex coordination of care* and *relying on an accessible and trustworthy team*.

These findings emphasize the problem that key elements of chronic care are not yet systematically implemented in SSc care. Most notably, we identified gaps in shared decision-making, goal-setting and individual counselling—all of which are vital tools to support patient self-management skills. Furthermore, there is a lack of complex care coordination tailored to individual patient needs.

The explanatory sequential mixed methods study[39] described in **Chapter 6** assessed eHealth literacy and needs regarding web-based support via internet-based information and communication technologies (ICTs). The quantitative phase included 101 patients and 47 providers; the qualitative phase collected data from

focus groups including Swiss/international patients, family members and HPs (n=17). Of the patients, 89.1% used ICTs at least weekly for private communication. Patients reported relatively high comprehension of eHealth information ($\bar{x}$=6.7, 95% CI 6.2–7.3, Range 1-10), but were less confident about evaluating information reliability ($\bar{x}$=5.8, 95% CI 5.1–6.4) or finding eHealth apps ($\bar{x}$=4.8, 95% CI 4.2–5.4). Both patients and professionals reported little experience with web-based self-management support.

Regarding acceptability criteria for ICT-based SSc management support, focus groups mentioned *considering non-ICT-accessible groups* and *fitting patients' and professionals' technology* as crucial. In relation to understanding/appraising eHealth, participants emphasized that general SSc information is not tailored to individual disease courses. Recommendations included *providing timely, understandable, and safe information* and *empowering end-users in ICT and health decision-making skills*. While professionals expressed concerns about lacking resources (financial, human), patients placed higher values on data security and person-centredness. Key eHealth drivers included *addressing end-user perceptions* and *putting people at the centre of technology*.

This chapter's results highlight patients' and HPs' shared need for training to support their uptake of eHealth resources. Key elements include guiding patients to timely/reliable information and using eHealth tools to optimize patient-provider communication. Regarding design, responsiveness to end-users needs and consideration for individuals with limited eHealth literacy and/or ICT access both also appear to be critical for acceptability.

Chapter 7 summarizes the key findings of the previous four chapters' research, discusses them in light of the existing body of evidence and suggests implications for clinical practice and policy. This is followed first by a reflection on the strengths and limitations of our methods, then by implications for future research.

This dissertation contributes to the scientific and clinical knowledge by strengthening a comprehensive perspective on SSc care needs and key elements of chronic care that require systematic implementation in the current management of this rare disease. It identifies four target areas for system change, all of which are particularly important for the reorganization of care toward an eHealth-facilitated integrated SSc care model: *shared and informed decision-making*, *complex care coordination*, *self-management and psychological support*, and *monitoring of integrated care programs*. These areas are elaborated under the overarching need for rare disease care that is specialised, accessible and patient-centred, and thus leaves no one behind[26]. For future model and program development, these findings provide the basic materials to bridge these gaps at the clinical, delivery system, and the health system levels.

Moreover, this dissertation's findings highlight the value of integrating patients and other stakeholders in every step of the development of a rare disease care model, beginning with a comprehensive contextual analysis. Equipped with the framework and methods used in this project, other researchers can use them to shed light on other rare disease populations' integrated care needs. As our experience has shown, the components of the eCCM are invaluable to develop both targeted programs and improved outcome measurements for eHealth-facilitated integrated care.

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Chapter 1 Introduction

1.1 Systemic sclerosis management

Systemic sclerosis (SSc) is a rare, multisystemic, clinically heterogenous autoimmune disease associated with a chronic and frequently progressive course.[1] While SSc can occur at any age, its onset is most frequent in persons aged 45-60.[2] For unknown reasons, women are 3-4 times more likely to develop SSc than men. International prevalence estimates are around 20 per 100'000 inhabitants, with wide variation worldwide.[3] The condition mostly affects connective tissue and small vessels, leading to fibrosis of the skin and internal organs.[1] This leads to irreversible scarring and eventually failure of the affected organs—particularly the heart, lungs, kidneys and gastrointestinal tract. Therefore, SSc is strongly associated with chronic morbidity and high mortality.[4, 5]

While prognoses for individual patients have improved over the past 20-30 years, mortality remains high, with a standardized mortality ratio (SMR) of 3.45 (95%CI 3.03-3.94).[5, 6] The cumulative 10-year survival has been estimated between 78.2% and 55.6% depending on the disease's severity.[7]

The variability of disease severity and clinical manifestations (e.g., autoantibody profile, disease progression, skin involvement) challenges diagnosis and management of each affected person.[1, 4] For the majority of SSc patients, vasospasm of digital arteries (Raynaud's phenomenon) and puffy fingers are the first symptoms noticed for which they may consult a physician.[8] As the disease usually manifests fully within 3 years after the appearance of Raynaud's phenomenon, early and accurate diagnosis and a tight follow-up program are critical to improve patient outcomes via ongoing monitoring and treatment of internal organ involvement.[4, 8]

SSc patients are typically grouped into two disease subsets: limited cutaneous systemic sclerosis (lcSSc) or diffuse cutaneous systemic sclerosis (dcSSc).[1] Notably, whereas dcSSc is associated with rapidly progressive skin fibrosis from the time of disease onset and early occurrence of visceral organ complications, lcSSc progresses more slowly, with fibrosis restricted to the distal extremities and face and later, less severe development of interstitial lung disease.[1]

Regardless of subset, however, SSc is a serious long-term condition with a broad range of symptoms that reduce patients' health-related quality of life (HRQoL).[9, 10] The most prevalent of these, affecting more than 50% of patients, are fatigue, Raynaud's phenomenon, hand stiffness, joint pain, sleep problems, skin tightening, muscle pain, muscle weakness, tender joints, itching, erectile dysfunction, vaginal dryness, shortness of breath, difficulty swallowing, digital ulcers, dry eyes, and mouth-, dental- and gastrointestinal symptoms. For patients living with SSc, the resulting disease burden and negative impact on physical and mental health can be severe.[11-13]

The main disease-related psychosocial stressors include work disability, body image dissatisfaction, fear of disease progression and sexual impairment.[14, 15] Regardless of disease severity (i.e., from a relatively mild to a severe form and/or progression), these stressors are associated with depressive symptoms.[14-16] Thus, the long-term care approach should be comprehensive, including both medical and psychosocial interventions.

1.1.1 Medical management

Although there is no cure for SSc, management of its associated complications, symptoms and psychosocial consequences can help improve patients' health and quality of life. Preventing significant morbidity and premature mortality requires lifelong multi-professional efforts and diligent patient self-management.[17, 18] Medical management of SSc differs fundamentally from that of most other autoimmune diseases, beginning with the fact that no basic treatment exists.[17] Except for autologous haematopoietic stem cell transplantation, which should only be proposed to patients with rapidly progressive dcSSc and a high risk of organ failure in an early disease stage, no current treatments modify the overall disease course.[17, 19]

As with other rare diseases, pharmacological treatment aiming to slow SSc's trajectory is impeded by a lack of sufficient evidence regarding potentially effective medications.[17] These include promising new therapies not yet included in existing recommendations. Therefore, treatment must to be tailored to individual organ manifestations—a process that requires regular multidisciplinary check-ups to assess problems without delay. This must be followed by both pharmacological (e.g., vasodilators, immunosuppressants) and non-pharmacological interventions (e.g., artificial nutrition, rehabilitation, self-management support).[17, 20]

Accordingly, the care of people with SSc focuses on interventions that speed the diagnosis of early organ involvement, and decrease or retard disease progression while reducing the risk of organ damage or failure.[17] At the same time, as interventions need to focus primarily on improving patients' quality of life, they should always be based on joint decisions between the patient and the provider, who must also weigh each proposed therapy's effectiveness against possible toxicities, side effects or other risks.[17, 20, 21]

Given SSc's complexity, medical management usually requires a combination of pharmacological and non-pharmacological interventions, i.e., those focusing on individual patients' medical and psychosocial needs. This process typically involves a team of healthcare professionals (HPs) from different specialties and professions.[17, 22, 23] In the context of this dissertation, we class all these physician and non-physician professionals as HPs, e.g., rheumatologists, nurses, physiotherapists, occupational therapists, psychologists and social workers.

Considering SSc patients' complex medical and psychosocial needs, in addition to multi-professional care, comprehensive, cross-sectoral family-oriented care is recommended.[24, 25] However, adequately evaluated disease-specific non-pharmacological interventions are not typically available for patients with rare diseases.[20, 26, 27] With a patient population as small and heterogeneous as that of SSc patients, it is difficult to conduct studies that can reliably identify effective treatment methods. To date, non-pharmacological care in SSc and patient-reported chronic care experiences have rarely been explored. To overcome the barrier posed by SSc patients' general sparcity, several ongoing collaborative initiatives currently aim to conduct multi-centre trials. By allowing larger samples, these will eventually allow evidence-based development of therapies and interventions.[27-29]

Despite the development of such research initiatives, the general lack of evidence-based recommendations and guidelines for SSc means that medical management and follow-up care still vary widely even between centres in the same county.[25, 30-33] SSc and rare diseases in general are challenged to define feasible and sustainable disease-specific care approaches.[34] Lacking such recommendations, especially for non-pharmacological management, and forced to choose between interventions that are not adapted to their target contexts (or even languages), not only care teams but entire healthcare systems

are hard-pressed to provide comprehensive, disease-specific, high-quality equitable care that is evidence-based and cost-effective.[29, 34, 35]

1.1.2 Living with the physical and psychosocial effects of SSc

People living with SSc face significant barriers to normal lives, not only because of their condition's diverse functional limitations, but also because of its severe psychosocial effects.[36-38] SSc symptoms can significantly hamper the performance of everyday tasks and work or social activities, with effects that spill into social roles, mental health and ultimately quality of life.[39-41]

The degree of disability in persons with SSc and its impact on quality of life is comparable or even greater than those in persons with more common chronic conditions, such as rheumatoid arthritis[38], diabetes[36] and obstructive lung disease.[42] A study including over 500 patients with SSc found HRQoL levels (measured via the Medical Outcomes Trust Short Form-36 (SF-36) questionnaire) significantly lower than for the general population, with most subscale scores similar to or lower than those reported for other chronic condition populations.[36] For physical functioning, the mean score was almost 1.5 standard deviations (SD) below that of the general population and considerably below those of patients with common chronic conditions, which were 0.5 to 1 SD below that of the general population.

For example, as occurs in cancer patients, illness-related fatigue is common in SSc patients, influencing HRQoL, daily functioning and social participation more than any other symptom.[37, 39] Concurrently, high rates of anxiety and depression were found among patients with SSc, with even higher rates in female patients.[43, 44] This correlation between SSc and depression was stronger in patients with SSc not only for age- and sex-matched controls[43] but also for patients with rheumatoid arthritis.[38] Using the Hospital Anxiety and Depression Scale (HADS), a recent Swiss study including 159 SSc patients found rates of anxiety, depression, mixed anxiety-depressive disorder (MADD) and distress respectively of 32.2%, 25.9%, 18.5%, and 49.5%.[45]

As with many rare chronic degenerative diseases, SSc's physical, psychosocial and resulting economic stressors are typically neither targeted nor assessed adequately by physicians or other HPs.[46-48] For persons with SSc, these neglected stressors include non-disease-specific consequences (e.g., sick leave, unemployment) as well as very common disease-specific problems [25, 49, 50]. In clinical studies, for example, persons with SSc commonly report a broad range of gastrointestinal symptoms (e.g., heartburn, incontinence, constipation, diarrhoea, difficulty swallowing, malnutrition) that severely reduce their HRQoL.[11, 51-54] On the other hand, gastrointestinal diagnoses are very likely underreported (and therefore underdiagnosed) because of social acceptability bias. For example, urinal and fecal incontinence are typically underreported by patients.[53, 55] Understandably, clinicians and researchers pay more attention to the symptoms patients report voluntarily than to those they do not; however, those that go unreported impact patients' lives enough to warrant some level of interrogation.[11, 51]

Similarly, few patient surveys query mental health and social problems. Nakayama's 2016 systematic review of 26 qualitative studies exploring the experiences and perspectives of SSc patients synthesized six dominant themes:[56]

1. Patients' described their experiences during the distressing "*transition in their appearance*" (i.e., radical facial changes and hand deformities). Many considered themselves terrifying, using terms such as "freak" or "Dracula" to describe their own appearance. Emotionally distressed, grieving the loss of their physical characteristics, they commonly tried to hide their appearance.

2. In addition, patients described instances when, overwhelmed by "*palpable physical limitations"* (i.e., skin hardening, loss of energy, mismatches between mental and physical capabilities), they were unable to accomplish basic self-management or even leisure activities.

3. Accordingly, "*social impairment",* including workplace inequalities, accompanied the sense of being unattractive or embarrassing to others.

4. "*Navigating uncertainty"* describes patients' explanations of how relieved they were when they finally received their diagnoses. Until then, they felt not only confused and misinformed by poor communication about their condition but terrified by SSc's unpredictable manifestations.

5. Even after their diagnoses, when they had opportunities to meet other patients in support groups, patients often felt "*alone and misunderstood."*

6. Eventually, some developed a "*gradual acceptance and relative optimism,"* as well as the confidence to deal with the disease.[56]

Interestingly, although financial burdens are very common in rare disease populations[48, 57], Nakayama et al.'s review (2016)[56] did not explicitly mention economic consequences apart from the loss of employment. Nor does Nakayama acknowledge the problem that, while persons with SSc emphasize the important emotional, informational and instrumental support they receive from close social relationships[58], they are also aware that their immediate and extended families bear many of their disease's physical, psychosocial and financial burdens.[59]

Therefore, congruently with more common chronic diseases, patients' and their families' self-efficacy is crucial to coping with the disease: prevent social isolation, depression and decreased quality of life.[60-62] A recent study revealed that greater self-efficacy in patients with SSc was associated with less pain interference and intensity.[62] After ensuring that patients have the self-management skills to cope with their conditions and solve individual problems, building their confidence in those abilities should be the primary focus of self-management support[60]. Especially in diseases as rare as SSc, several qualitative studies have found that patients feel marginalized and misunderstood when their specific problems and their impacts on their lives are not recognized; therefore, it is vital that patient education and self-management support be disease-specific.[47, 56, 63, 64]

1.1.3 Burden and cost of illness

In Europe alone, there are currently over 6'000 active rare diseases, each of which affects fewer than 5 in 10'000 individuals.[65] However, while the diseases themselves are rare, their cumulative reach is considerable: rare diseases are estimated to affect 6–8 percent of the global population. And for the affected persons, the burden and lifetime cost of illness (COI)—including direct healthcare costs (e.g., hospitalisation, drugs, home healthcare), direct non-healthcare costs (e.g., social services, transportation), informal care costs and indirect costs (e.g., sick leave, unemployment)—can be extremely high.[66]

SSc patients have high annual medical costs and healthcare resource use. This is especially true for those with serious disease complications and more pronounced functional disability.[67-69] The average yearly cost per patient (including direct, indirect, and lost productivity costs) range from 11,073 Euro in Italy[70] and 22,459 Euro in France[67] to $17,365 (approx. 15,498 Euro) in a large US SSc population[71] and 18,453 Canadian dollars (approx. 12,600 Euro) in a large Canadian sample.[72] Specific costs vary based on demographic and disease-related factors, e.g., younger age, greater disease severity and comorbidity and skin involvement, poor overall health status, lung disease, gastrointestinal bleeding, renal disease, and

physical disability, all of which contribute to SSc patients' high rates of hospitalization, physician appointments and early retirement.[67, 70, 71, 73]

In Switzerland, the first report of the national Swiss EUSTAR (EUropean Scleroderma Trials And Research) project in 679 SSc patients.[74] Compared to its European counterpart, the Swiss cohort included a higher proportion of male patients (25% vs 16% European, p=0.005) and higher prevalences of early/mild and very early/very mild patients (26.1 vs 8.5% European and 14.9% vs 6.7% European, respectively, p<0.0001 for both). These proportions indicate that many of the Swiss patients were diagnosed at early stages of the disease. However, despite early diagnosis, for unknown reasons, more severe disease progression (especially in the lcSSc subset) was observed in Swiss patients. Such an imbalance emphasizes the high burden of disease for SSc patients in Switzerland. Also in spite of the expected advantage of early detection, compared to the European cohort, the Swiss cohort showed no significant differences regarding either survival or long-term outcomes.[74]

For the year 2013, Swiss SSc patients had a mean length of stay (LOS) of 11.17 days.[75] In studies of other patient groups, mean LOS ranged from 5–7.5 days, with hospitalization representing 60% of all healthcare costs.[67, 76, 77] These data suggest that SSc entails both a high disease burden and high disease-related costs. Despite SSc's rarity, both are highly relevant to the affected patients and to society as a whole.

1.1.4 Complex chronic care needs

Like other patients with rare diseases, patients with SSc typically experience difficulties and delays receiving accurate diagnoses, reliable information on their condition, and appropriate treatment.[47, 56] Within 1-5 years after diagnosis, most patients develop clinical manifestations, often entailing extensive organ damage.[4] Minimizing these effects demands timely, person-centred care tailored not only to their specific physical and psychosocial concerns, but also to their ability to travel to specialized treatment centres.

Regarding SSc care provision, various studies have identified serious systemic shortcomings in SSc care, from diagnosis, care delivery and self-management support coordination through long-term follow-up.[18, 25, 32, 33, 78-80] To address these needs, several advanced healthcare systems have devoted considerable resources, particularly regarding HPs trained to provide SSc-specific diagnostic services, therapeutic strategies, and self-management support.[33, 68, 78] Persons within manageable distances of these centres receive the best available care either as out- or inpatients. For those who live farther away or have more limited mobility, access and referrals are commonly limited to inpatient settings and vary widely between countries and centers.[25, 33, 68, 78, 81]

For example, in the Netherlands, while the numbers of visits to specialized HPs (both physicians and non-physician) are comparable across the healthcare system, these visits are still less frequent than would be expected given the complexity and severity of SSc.[68, 78] In 2013, patients in the Sint Maartenskliniekin, a specialized facility in Nijmegen, reported contact with a median of eight disciplines since the onset of their SSc, and a median of 4 over the preceding 12 months; over the same period, their median numbers of visits to SSc-specialized (physician and non-physician) HPs were 7 and 7.5, respectively.[78] Still, there were broad disparities regarding the specialists visited: 53% were to physiotherapists, 15% to nurse specialists and 7% to psychologists.

A similar distribution applied to another study from the Netherlands—this one conducted at Leiden University Medical Centre the following year. In that case, for the previous 12 months, while patients

reported a median number of 4 visits to physicians, the numbers of visits ranged from 0 to 14.[68] As with the Nijmegen study group, a sizeable majority of the previous year's specialist visits (61%) had been with non-physician HPs. And as in Nijmegen, roughly three-quarters (73.1%) of the Leiden group's specialist visits were to the same three groups: 57.5% were to physiotherapists, 12.5% to nurse specialists and 3.1% to psychologists.

Research on SSc health service use in Eastern European countries—which has thus far been restricted to a single Hungarian study—reports similar figures for annual specialist physician visits (mean 7.1, SD 7.6) and physical therapy use (61.3%).[81] While that study did not collect data on visits with other non-physician specialists (e.g., nurses, psychologists), it identified physiotherapists as the most frequently visited HPs. Whether in the Netherlands or in Hungary, though, one major factor sets this group apart from physicians, nurses, or psychologists: patients typically have access to appropriately qualified physiotherapists outside of specialized centres.[33, 81] Unfortunately, none of the cited studies assess patients' geographic distributions (i.e., travel distance to large centres); nor do they report their median numbers and ranges together. Such information would likely explain much of the variability of health service use. To our knowledge, only one research team has addressed this topic: Robson et al. (2020)[25] attributed disparities in access to specialist psychological support across the United Kingdom partly to patient location/treatment facility type (i.e., district general hospital, teaching hospital, National Health Service (NHS) specialist centre) and partly to the treating physician's speciality (i.e., nephrology vs. rheumatology).[25]

Altogether, SSc patients' and their families' experiences echo those of many other rare disease patient populations, who commonly face major disparities concerning their access to and quality of specialized healthcare.[18, 25, 32, 33, 79, 80] Several researchers have identified significant shortfalls in SSc care regarding diagnostics, multidisciplinary assessment, access to individualized disease-specific care, and alignment of treatment goals and communication between non-physician HPs and rheumatologists.[49, 64, 78, 82-84]

Despite the broadly recognized importance of multi-professional, multidisciplinary care, referrals to and interventions by specialized non-physician HPs vary widely among centres and countries.[18] This shortage reflects partly the general lack of evidence-based recommendations for non-pharmacological management and partly the widely-varying conceptions regarding interprofessional collaboration. Researchers from Belgium and the Netherlands, for example, revealed that physicians' illness perceptions and knowledge about other professions' relevant competencies may influence both the information and the care patients ultimately receive.[18, 79, 85] And regarding the interprofessional alignment of treatment goals, Willems et al. (2015),[18] found that physicians' reasons for referrals to non-physician HPs focussed mainly on bodily functions and structures, e.g., joint stiffness or pain, while non-physician HPs treatment options were more likely to target patients' abilities to recognize and cope adequately with disease-related issues such as new symptoms or emotional distress. Likewise, concerning their evaluation of disease severity, physicians tended to emphasize different aspects than their patients.[12] Jaeger et al. (2018)[12] found major differences between the factors driving patients' perceived levels of disability (i.e., dyspnoea, pain, digital ulcers, muscle weakness and gastrointestinal symptoms) and those influencing physicians' evaluations. In particular, whereas patients' perceptions spring from personal/subjective experience, physicians tend to focus their main attention on objective measures (e.g., lung function testing, pulmonary arterial pressure).

Furthermore, self-management support is a vital component of all chronic and rare disease care.[60] As noted above, congruently with other rare disease populations, persons with SSc and their families have

broad, largely disease-specific informational, educational and self-management needs.[25, 86] In SSc, these needs are mainly focused on understanding and managing the disease, e.g., support to manage different therapies, adjust and prioritize daily activities and cope with psychosocial developments.[40, 87-93]

For example, even as patients in Pettersson et al.'s qualitative study (2020)[63] described their experiences with physical activity and exercise as essential for their health, they also expressed worries about possible adverse effects and a need for guidance when exercising. In a qualitative study in Switzerland, SSc patients reported that they had to find their own "therapy mix" by trying different options.[94] Still, such options are by no means widely available: a more recent study from the United Kingdom including 120 HPs (34% specialist nurses, 51% doctors, 12% allied HPs) found that, regarding self-management programmes for people with connective tissue diseases (CTD) and systemic vasculitis, patients could only access self-management training in 23% of rheumatology departments, and psychological support in 32.8%.[25] In that case, participating HPs reported that they would need additional training to provide self-management and psychological support. Similarly, in the Netherlands, Stocker et al. (2020)[49] found low numbers of referrals to HPs who dealt with SSc patients' psychosocial needs.

Regarding coordination of care and follow-up organisation, rare disease patients commonly see a wide range of specialists, leading to difficulties assimilating information, making decisions and even coordinating their many appointments.[95] As members of this group, we surmise that persons living with SSc need to find highly-qualified HPs not only in whom they can confide, but who are available for discussions of individual problems as well as long-term monitoring and support across the course of the disease.[47, 64, 96] In a survey including 650 SSc patients from 13 Dutch hospitals, well-structured multidisciplinary collaboration (46%, n = 298) was among the three highest-rated process indicators.[97] However, almost half (48.9%, n=158) perceived that the collaboration between rheumatologists and non-physician HPs was never or only sometimes sufficient.[49] Regarding follow-up organisation, the quality of care perceived in Dutch expert centres was significantly better compared with that in regional hospitals (standardized mean difference -0.35, 95% CI (-0.49, -0.22), $P < 0.01$).[97] Additionally, it is known that individuals living with rare diseases and their families can benefit from peer support and online communities that help them cope with their diseases' physical, emotional and psychosocial consequences.[86, 98] In SSc, peer support groups have existed for many years; however, lack of knowledge about what happens at support group meetings and not having reliable transportation to and from meetings are common barriers for SSc patients.[99] These examples highlight the difficulty of providing high quality coordinated care for a rare disease such as SSc.

1.2 Rationale for reshaping systemic sclerosis management

Given the complexity of SSc care, the many patient needs that go unmet and the magnitude of the challenges that face individual HPs, the entire current SSc care model requires optimizing and restructuring. Based on chronic care approaches combined with a variety of internet-based information and communication technology (ICT) solutions, integrated care models have already been successfully employed to reshape standard chronic illness management. However, for rare diseases such as SSc such models remain scarce.

1.2.1 Integrated care model requirements for rare disease management

Care pathways for rare disease patients are often complex, including large numbers of HPs.[48, 95] Therefore, safe, effective high quality care demands extensive collaboration and care coordination. In Europe, most patient care is organised by academic medical centres, which have traditionally been

designed to focus on acute rather than chronic health problems. But while the centres that specialize in diseases as rare as SSc generally include mechanisms to improve their diagnostic and therapeutic approaches, they generally lack a coordinated approach that provides for the complex care needs of either the patients or their families.[28, 34]

The most effective new care models restructure such systems, integrating mechanisms that ensure holistic, coordinated and continuously improving care that focuses on meeting long-term chronic care needs.[29, 34, 60] Compared to patients with widespread chronic illnesses, rare disease patients still face major health disparities concerning access to diagnosis, disease information, appropriate quality health care, and available treatments.[47, 100] Their challenge is to obtain timely, person-centred care tailored to their specific health problems, psychosocial concerns and ability to travel to the specialized treatment centres that deliver most interventions for patients with rare diseases.[95, 101]

Similarly, the care models currently used for SSc patients are only sparsely described in the literature and commonly include no comprehensive chronic care approach. To date, only Spierings et al. (2019),[102] a Dutch research group, have collaborated with patients and HPs to identify priorities and recommendations aimed at improving SSc chronic care. The authors highlighted the importance of shared care/multidisciplinary collaboration, medical data exchange, information for patients and HPs, patient empowerment and non-pharmacological approaches for SSc management.[102]

Particularly concerning in this regard is the shortage of SSc-specialized healthcare providers: on the contrary, this field's HPs typically report substantial educational deficits, especially concerning effective non-pharmacological interventions.[18, 25, 96] As a result, HPs have no option but to pioneer their HP competencies as they go. Understanding the effects of this system, combined with piecemeal coordination, on patient care experiences and disease outcomes will require further study. For SSc and similarly rare chronic illness populations, not only the introduction of new modes of care delivery (e.g., online health interventions) and higher standards of non-pharmacological care, but also the consolidation of expertise within and between countries will vastly improve both continuity of care and access to that care.[18, 103, 104]

As a recent example, in the European Scleroderma Trials And Research (EUSTAR) project, compared with the overall European cohort, the Swiss research group identified a shorter mean period between the appearance of their group's diagnoses and their first visits to expert tertiary centres.[74] In fact, Swiss healthcare policy provides patients with rare diseases fast access to specialized care. By opening direct channels of communication and by establishing standards for how that communication is structured, a new care model would speed both the flow and the quality of care-relevant information, reducing such regional disparities.

In chronic disease populations with established treatment patterns, expediting diagnosis and treatment generally leads to improved patient outcomes. However, despite Swiss SSc patients' early treatment, their long-term outcomes (including survival) were no different from those of other European patients. One possible explanation for this apparent mismatch is that, while Hernandez et al. (2021)[74] supported prioritizing earlier referral to expert centres for SSc care to reduce organ damage, we currently know little about the relationship between such centres' services and patient outcomes.

Similarly, the current literature includes extremely few Swiss reports on non-pharmacological SSc care options. One qualitative study examined self-management support in Swiss SSc patients and their families, revealing significant care gaps.[94] In that case, participants described how they had to cope alone

with the lack of information on SSc's pathophysiology, distressing symptoms such as disfigurement, and other impacts on their family and working lives.

Unfortunately, in the absence of a disease-specific integrated care plan, little protects patients from such gaps in knowledge and care. The common recommendation is to establish centres of expertise in rare disease that ensure continuity of care through all stages of their patients' illnesses.[34, 105] By reducing delays in diagnosis and treatment, such continuity correlates with better-adapted care, fewer adverse consequences and reduced healthcare costs.[106] Therefore, to improve rare disease patient care, the most promising options are integrated care models that incorporate new technologies and innovative approaches and are driven by patient needs.[34]

The World Health Organization (WHO) defines integrated health service delivery as "an approach to strengthen people-centred health systems through the promotion of the comprehensive delivery of quality services across the life-course, designed according to the multidimensional needs of the population and the individual and delivered by a coordinated multidisciplinary team of providers working across settings and levels of care. It should be effectively managed to ensure optimal outcomes and the appropriate use of resources based on the best available evidence, with feedback loops to continuously improve performance and to tackle upstream causes of ill health and to promote well-being through intersectoral and multisectoral actions".[107] Complementing this definition, Kole's "Recommendations from the Rare 2030 foresight study" highlight the need for integrated care, i.e., person-centred long-term care that both integrates HPs across medical disciplines and bridges the gaps between medical and social spheres.[34] At the national level, treatment strategies for rare disease should include funds and incentives to coordinate care across health sectors (with a particular focus on eHealth opportunities), as well as to ensure the provision and reimbursement of multidisciplinary/non-pharmacological care and its coordination.[34, 108]

In rare disease populations, care models that include coordination and continuity of care correlate very well with improved satisfaction and quality of life while reducing healthcare costs.[106, 109] However, given these populations' small sizes, convincing policymakers to allocate the funding necessary to develop, test and implement such models can be difficult. One UK study analysing the care of patients with Alstrom syndrome (a rare genetic disorder) showed that patients with access to highly specialised patient-centred and coordinated health services were more satisfied with their care than those receiving usual care from the British National Health Service.[106] In the same study, treatment adherence, clinical attendance, and quality of life were all higher in patients treated by specialised services. As an added benefit, because the specialised care group required significantly fewer clinic visits, their net costs were comparable to those of the group who received standard care.[106]

Further, regarding care continuity, interventions should not be limited to hospital settings. Successful integrated care strategies often include technological (e.g., web-based) intervention components to reach people in their homes and workplaces.[110] For example, Dwyer et al. (2014)[86] found that patients living with congenital hypogonadotropic hypogonadism (a rare, treatable condition that manifests as absent or incomplete puberty with infertility) were highly motivated to use web-based interventions to contact not only expert healthcare providers, but also peer-to-peer support groups. Recommendations from the Rare 2030 foresight study highlight the need to reduce healthcare inequalities in people living with rare diseases, suggesting that this goal is achievable via eHealth services provided to patients by online specialists regardless of location or nationality.[34]

For SSc, the EUSTAR project report recommends that, upon diagnosis, patients be referred to specialised centres.[111] In Switzerland, within the scope of the "Gesundheit 2020" national health policy priorities, the Federal Council approved a national programme for people with rare diseases to improve first diagnosis, then access to high quality care throughout the courses of their diseases.[112] In addition to that programme's description of 19 interventions, its identification of reference centres for individual diseases or disease groups deserves special attention. To date, Switzerland has recognized nine centres for rare diseases. These coordinate the care both of patients diagnosed with rare diseases and of those with no confirmed diagnoses.[113] For the latter group, each centre ensures that each patient receives a point of contact, as well as timely referrals to specialists for diagnosis and treatment. Patients who have already been diagnosed receive care in disease-specific reference centres where expertise is pooled. The associated HPs coordinate their tasks within their teams and networks, while working together on evidence-based treatment guidelines.

However, as of 2021, disease-specific expert centres and their respective integrated SSc care models remain to be defined for Switzerland. Numerous challenges affect efforts to develop and implement integrated care models. Internationally, the most serious of these include fragmented and sub-optimal quality of care, increasing healthcare needs and expectations, poorly functioning information technology (IT), poor coordination of finances and care pathways, conflicting objectives, high costs, resource shortages (financial, human) and insufficient incentives for their adoption.[108, 114, 115] In Switzerland, the major barriers are fragmentation of healthcare due to individual cantonal regulations, cultural heterogeneity (i.e., the German-, French-, and Italian-speaking regions) as well as the absence both of an interoperable IT communication tool (i.e., a unified national electronic health record) and of a federal regulatory framework for integrated care.[108, 114]

Further complicating the introduction of new integrated care models, high out-of-pocket (OOP) contributions (i.e., personal payments for medical services not covered by insurance) increase the patient burden.[114] Compared with European standards, the proportion of OOP payments is exceptionally high in Switzerland, accounting for roughly 26% of total health expenditure (compared to the EU average of 16%). This strongly influences the provision of outpatient and follow-up care in Switzerland, as inpatient hospital services are predominantly funded from public sources. For patients with SSc, the fact that OOP contributions are also necessary for dental care and complementary therapies very likely leads some individuals to postpone or forego necessary care.

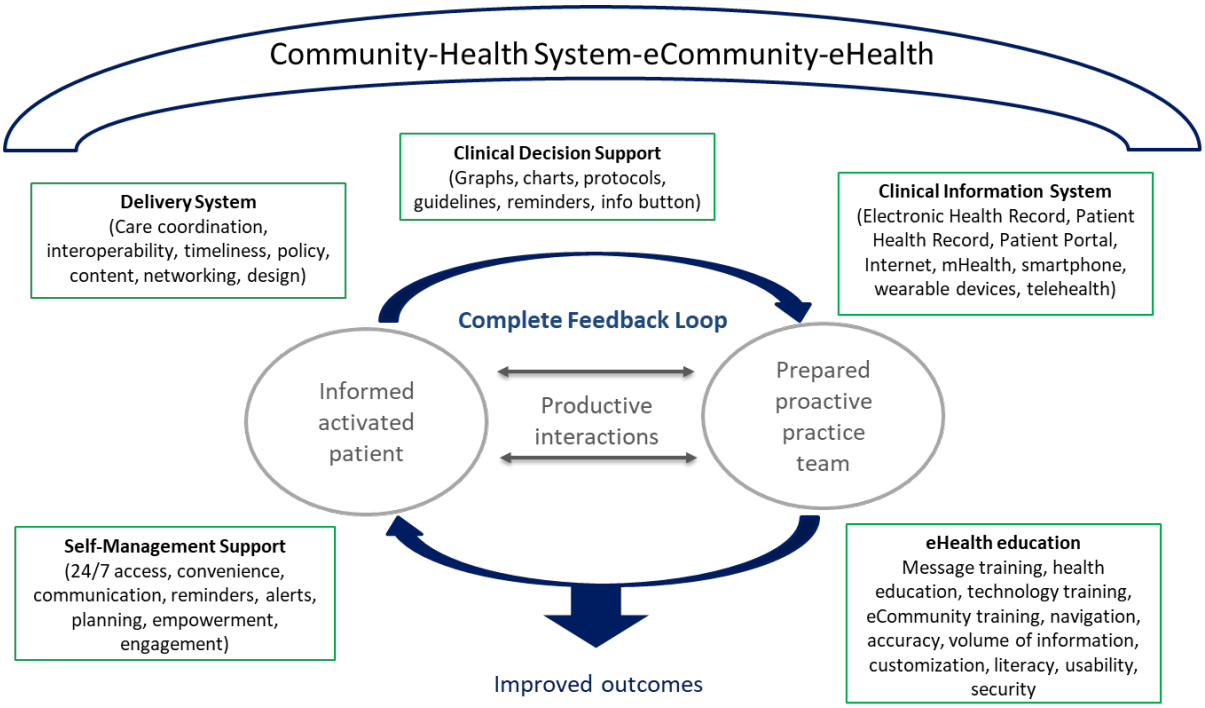
Before planning can begin on a new care model, research will be necessary both to analyse each target context and to explore SSc patients' and their families' specific chronic care needs. Until the project is complete, the latter task will require ongoing close engagement between the interventionists and representatives of all stakeholder groups, i.e., patients and their families, healthcare providers, patient associations, researchers, and health policymakers.[34, 116] To ensure that the new care model addresses both the biomedical and the psychosocial consequences of SSc, while involving patients as active partners in their own care, established guidelines describe how to shift clinical practices from an acute care delivery system to an innovative integrated chronic care model for patients living with a rare disease.[117, 118]

1.2.2 Theoretical framework: eHealth enhanced Chronic Care Model

Based on the Chronic Care Model (CCM)—a widely-used reference model for chronic care improvement—a number of components are necessary to improve the quality of chronic illness management.[117] Considering that internet-based information and communication technology (ICT) applications (eHealth) have become increasingly recognized tools to improve or support patients' health, the CCM was amended in 2015 to include them.[110, 117, 119]

Broadly, the updated eHealth-enhanced chronic care model (eCCM) aims to improve health outcomes through effective and productive interactions between prepared, proactive practice teams and informed, activated patients by systematically focusing on seven key interdependent component classes: (1) community resources; (2) healthcare system considerations; (3) self-management support; (4) the care delivery system; (5) clinical decision support; (6) the local clinical information system; and (7) eHealth education (**Figure 1**). Critically, the eCCM treats productive interaction between patients and healthcare providers as an essential factor of successful chronic care. Thus, to foster patient activation and cooperative partnership, each eHealth intervention must include a closed or complete feedback loop (CFL).[110]

Figure 1. Gee et al.'s eHealth-enhanced Chronic Care Model (eCCM)[110]



In conjunction with the eCCM[110, 117], numerous eHealth tools to support chronic illness management have been used to improve patient engagement and optimize health outcomes for patients with diverse common chronic conditions (e.g., diabetes, cardiovascular disease, depression, osteoarthritis).[120, 121] Also, evidence suggests that the presence of multiple eCCM elements, e.g., self-management support alongside clinical decision support, is associated with improved clinical outcomes, including reduced health service use, emergency department visits, all of which also reduce healthcare costs.[122-125]

For example in diabetes patients, implementation of eCCM elements was shown to improve HbA1c and low-density lipoprotein (LDL) levels, reducing both health service use and risk for cardiovascular

disease.[121, 126-128] Similarly, in rheumatic diseases, combinations of eCCM elements, including psychological, educational and self-management interventions, exercise programmes and web-based patient decision aids, have been shown to improve functional disability, pain, fatigue, social function, mental health, depression, and self-efficacy[129, 130] and patient active role in medical decision-making[131], although eHealth apps have yielded poor impacts on outcomes in rheumatic diseases.[132]

Thus, recent recommendations of the European Alliance of Associations for Rheumatology (EULAR) for the care of people with inflammatory arthritis highlighted the importance of interventions to provide patient education and self-management, as well as to bolster problem-solving and goal setting skills.[133] Alongside these, they stressed the value both of cognitive behavioural therapy and of participation in patient organisations. In addition to recommending that HPs promote and include such support elements in their routine management of people with inflammatory arthritis, the recommendations stressed eHealth's essential role in empowering patients while maintaining a holistic and patient-centred approach to care.

1.2.3 eHealth-facilitated chronic care in rare rheumatic diseases

Unlike with common chronic conditions, eHealth-facilitated chronic care strategies focusing on rare disease patients' self-management, collaboration with patients and their families, preventive measures, decision making support, continuity of care and use of clinical information systems are very rarely established.[29, 60, 134-136] Existing models emphasize matching interventions as closely as possible to the local context, but rarely rely on an integrated care framework.[135] Similarly in rare multisystemic, autoimmune connective-tissue diseases such as systemic sclerosis (SSc) and systemic lupus erythematosus (SLE), there is paucity of evidence on eHealth-facilitated integrated care. Several studies have demonstrated that patients with rare connective-tissue diseases and their providers are interested in web-based education and support.[102, 104, 137] However, web-based resources often offer poor quality, low readability and limited functionality;[138-140] few focus on critical concepts such as health equity or patient engagement and empowerment.

One notable exception is the Lupus Interactive Navigator, a web-based self-management program for SLE with high patient ratings of content, usability and acceptability.[141] This program was adapted from a web-based tool originally developed for cancer patients, developed based on a comprehensive needs assessment, and co-designed toghether with several stakeholders (e.g., patients, clinical experts, programmers, researchers). The authors summarize, that the online self-management program delivers unique support to people living with SLE, however, it may be most helpful for individuals with newly diagnosed persons.[141]

In SSc, several studies have shown that eHealth-interventions can support high-quality care by delivering reliable disease information, self-management support, and disease monitoring.[142-145] **Table 1** summarizes the relevant eCCM dimensions, along with corresponding key actions and examples of components shown to be effective and feasible for people living with common rheumatic conditions (i.e., osteoarthritis, rheumatoid arthritis, chronic pain, fatigue), rare rheumatic diseases (i.e., SSc, systemic lupus erythematosus, vasculitis) and other rare conditions (i.e., congenital hypogonadotropic hypogonadism, cystinosis). Despite promising initial indications, though, little is known about SSc patients' and health professionals' eHealth literacy or how eHealth can be applied to effectively inform decisions regarding clinical practice and daily life. Answering such questions will require an exploration of how web-based technologies can best facilitate access to high-quality, coordinated SSc care. Similarly,

developing targeted, user-centred interventions that will be accepted and adopted will require first understanding the full range of stakeholders' eHealth literacy, needs and perspectives.[146]

Table 1. eCCM dimensions, key actions and example components for common/rare rheumatic diseases and other rare conditions

eCCM dimension	**Key actions**	**eCCM example components**
Community resources	Provide support for patient engagement or activation and for self-management[147], including online communities and health-related social networks (eCommunity)[110]	*Increased access to effective programming within the relevant communities* via connections with agencies focused on rheumatic/rare diseases, particularly regarding collaboration between HPs and patient organisations[133, 148] *Access to counselling or peer-support groups, including online support groups and communities* for rare diseases such as cystinosis and congenital hypogonadotropic hypogonadism[98, 148]
Health system	Formulate and execute strategies to implement chronic disease improvements and eHealth technologies to improve access to care, reduce costs, and empower patients and caregivers[110, 121, 147]	*Representation of chronic illness improvement in the organization's goals* and quality improvement plan for rheumatoid arthritis care[149] *Financial and nonfinancial incentives* to providers to influence clinicians' practices regarding rare disease management[150] *Use of Personal Health Records (PHR)* to reduce face-to-face visits in musculoskeletal conditions[151]
Self-management support	Shift the focus from patient education to encouragement and support for effective self-management, which improves clinical outcomes and reduces healthcare use and costs[127, 147, 152]	*Collaborative assessment, goal setting, action planning, and problem solving in routine care*[133] *Individual and group interventions* (disease-specific or generic) including *web-based interventions* that emphasize behaviour change, patient empowerment and the acquisition of self-management skills in people living with common rheumatic diseases[130, 133, 153] *Dedicated psychological support and self-management/exercise programmes* for people with connective tissue diseases such as SSc, systemic lupus erythematosus and vasculitis[25, 92, 141-143, 154] and rare diseases [101]

		Whole-team approach: specialist teams empowering people with rare (rheumatic) diseases to manage their own care[25, 106] *Learning sessions/staff training* for HPs in rheumatology to foster the provision of self-management support in rheumatic/rare diseases (e.g., brief psychological interventions), signposting to help patients connect with resources, including patient organisations[25, 133]
Delivery system	Formulate policies that facilitate electronic interoperability/ exchangeability of data between healthcare systems[110] Ensure patient access and control over personal health data (i.e., PHR) and resources at the provider level to promote PHR use[110] Ensure a complete feedback loop (CFL) between patients and providers	*Online screening services* to promote early detection of rheumatic diseases[155] *A multi-component intervention* for patients with rheumatoid arthritis consisting of an informational leaflet, a patient-held record and guidance from a specialized rheumatology nurse, can improve patient involvement in disease activity-based management and reduce inequalities between patients regarding their capacity to participate in shared decision making[156] *Chronic disease management care models* for patients with osteoarthritis: Small to moderate effects on process and health outcomes were found[122] *Building capacity for co-management by consumers*: Patients with rheumatic diseases can refer themselves for lab tests and access their test results online[151, 155] Patients with rheumatic diseases can choose between physical or online visits[155] *Home-based chronic wound management* with real-time quality feedback *using a mobile health* (mHealth) tool for remote self-assessment of digital ulcers (DUs) in patients with SSc[157] *Internet-Based Cognitive Behavioural Therapy* for patients with chronic fatigue syndrome[158]

Clinical decision support	Assure that providers and patients have access to the most current evidence-based clinical guidelines, protocols, and care/self-management standards[110]	*Computer-based decision support systems (CBDS) for healthcare providers* may improve management of chronic pain and optimize specialist utilization[159] *CBDS shared by patients with rheumatic diseases and providers*[131, 160], such as the computerized, individualized, culturally tailored lupus decision aid[161]
Clinical information systems	Enhance clinical information systems (CIS), including CCM elements (e.g, Electronic Health Records (EHRs), PHR, registries, access to current standards of care)	*Giving patients with rheumatic diseases access to their PHR* to improve their empowerment[162]: Introduction of the PHR was shown to be feasible and increased satisfaction with care in young adults with juvenile idiopathic arthritis and parents of children with rheumatic conditions[163, 164]
eHealth education	Support chronically ill adults' and their care providers' development of eHealth skills[110 165] Provide leadership support and other necessary resources when introducing eHealth[166]	*Evaluation of eHealth literacy and perceptions* among patients with rheumatic diseases and healthcare providers[166-168] *Provide equipment and training for patients and providers* to improve eHealth literacy and reduce digital stress/inequality[165, 169]

1.3 How to assess eHealth-facilitated integrated care

Assessing the quality of an integrated care model is not a straightforward task: a care model is more an overarching strategy than a specific intervention.[170] As for quality itself, for the purposes of this thesis, we subscribe to the World Health Organization (WHO) definition of quality in health services as a signifier of the extent to which they improve people's health. This, in turn, depends on how effective, safe, people-centred, timely, equitable, integrated and efficient those services are.[171] Of these seven characteristics, three—people-centredness, integration and efficiency—particularly imply focus. Their antithesis is a much-discussed issue in healthcare: fragmentation. This tendency is one factor models of integrated care are designed to reverse.[170, 172]

Fragmentation includes not only institutional divides due to the high levels of specialization (i.e., treating each aspect of a complex condition separately), but also organizational disunity regarding health and social care or gaps in care, e.g., during periods when patients are transitioning between care settings (e.g., from hospital to home). Based on an extensive systematic literature review, Hughes et al. (2020)[170] concluded that the development and evaluation of integrated care was based on four perspectives: patients' perspectives, organizational strategies and policies, conceptual models, and theoretical and critical analysis.

Of these four, given that the primary object of care integration is the improvement of patient outcomes, its primary perspective is that of the patient.[34, 170] Thus, from the planning phases through development and evaluation, new eHealth-facilitated chronic care models rely extensively on patient-reported experiences and outcomes. These allow the developers first to understand the current state of care (e.g., contextual factors), and later to monitor their models' success. Along the entire disease continuum, patient-reported experience measures (PREMs) provide insights into patient care experiences—feedback to improve patient care.[173] At the same time, patient-reported outcome measures (PROMs) such as HRQoL provide valuable and unique information, on medical conditions' or interventions' impacts on patients.[174] Particularly, the assessment of HRQoL is a cornerstone in SSc chronic illness management, both to address disease consequences and to evaluate care. Both PROMs and PREMs can be used to comprehensively evaluate complex integrated care strategies from a patient perspective.

To assess integrated care in rare diseases as SSc, one further complicating factor is that patients tend to be geographically scattered. Consequently, investigations of care quality from the patients' perspectives are typically hampered by the lack of PROMs and PREMs validated for their populations, languages or settings.[175, 176] Fortunately, both the Patient-Reported Outcomes Measurement System (PROMIS) (U.S. National Institutes of Health) and the EULAR Outcome Measures Library provide repositories of cross-culturally validated PROMs for rheumatic and musculoskeletal diseases.[177, 178] Additionally, the Outcome Measures in Rheumatology (OMERACT) initiative strives to improve endpoint outcome measurement through a data-driven, iterative consensus process involving relevant stakeholder groups.[179] Importantly for PROMs in rheumatology, which are particularly useful in newly diagnosed patients, minorities and those with low income or poor self-reported quality of life, a positive patient experience with reporting was found to be critical for their successful implementation.[180]

Well-implemented PROMs can build care providers' understanding of each patient's specific concerns, e.g., regarding symptoms that cause the most distress or otherwise go unreported. In such cases, they enable or augment patient-provider communication and shared decision-making. However, recent research has also highlighted a lack of rheumatic disease-relevant outcome measures that would support the evaluation of complex and non-pharmacological interventions and communication (i.e., medication adherence, shared decision-making).[181, 182] Similar gaps exist regarding measures focusing specifically on eHealth technology and interventions.[183] This includes outcome measures that incorporate operational aspects of healthcare delivery and patient care experiences, such as care delivery processes and PREMs.[149, 173]

Similarly in SSc, PROM and PREM data provide important perspectives on patient health status, quality of life and care experiences when aiming to assess healthcare quality.[16, 184] As for most rare disease, though, few PROMs and PREMs have yet been specifically developed and validated for SSc.[31, 185] While a number of non-disease-specific PROMs have been validated for SSc[184], their use in clinical practice and research often fails to capture certain major patient problems, including psychosocial issues.[186, 187] Also, Mattson et al. (2015)[186] noted that randomized controlled trials (RCTs) of patients with SSc tend not to collect data on individual factors such as personal history, motives (e.g., needs, goals, intentions) and patterns of experience and behaviour (e.g., habits, lifestyle). This observation indicates a need for more measurements focusing on these patients' pre-disease experiences, major life events, motivational influences, and personal interests and goals.[186]

To assess SSc's overall disease impact, an international research group developed and validated the EULAR Systemic Sclerosis Impact of Disease (ScleroID) questionnaire in collaboration with a joint team

of patients with SSc and medical experts.[188] Together, they identified four main drivers of disease impact: Raynaud's phenomenon, fatigue, impaired hand function, and pain. Compared with non-disease-specific PROMs, ScleroID scores yielded good Spearman correlation coefficients and internal consistency (Cronbach's alpha 0.87, similar to the Scleroderma Health Assessment Questionnaire (SHAQ, 0.88) and higher than for the European Quality of Life 5 Dimensions (EQ-5D) questionnaire (0.77)). The ScleroID's main weakness is that, as noted by Mattson et al. (2015)[186] and Stamm et al. (2011)[187] it is limited to bodily impacts, with no items that measure personal factors (e.g., paid work, support from others) or experiences (e.g., with healthcare organizations or non-pharmacological care).

To bridge that gap, the first PROM to assess HRQoL in people with SSc regarding both physical and psychosocial disease consequences is the Systemic Sclerosis Quality of Life Questionnaire (SScQoL).[189, 190] To date, the SScQoL has undergone cross-cultural adaptation and validation in six European countries.[189] Published findings suggest a seamless adaptation across five of those countries, allowing direct comparison of their measurements (for further information see section 1.3.1).

No established disease-specific core set of PROMs is yet available to evaluate SSc outcomes.[31, 185] And regarding PREMs, the selection validated for SSc currently leaves considerable gaps. In particular, psychometrically sound process and outcome measures to evaluate eHealth technologies and their effects remain scarce.[183]

1.3.1 Systemic sclerosis quality of life (SScQoL)

To measure generic HRQoL in SSc populations, previous studies used non-disease-specific instruments such as the EQ–5D, the HAQ, the Patient-Reported Outcomes Measurement Information System–29 (PROMIS–29) and the short-form 36 (SF-36).[184] Such questionnaires usually cover physical, social, psychological, emotional, cognitive, spiritual, work- or other-role-related and financial impact domains. Despite generally not capturing SSc-specific problems such as patient concerns with physical appearance and uncertainty about future disease progression, then, they have been used widely in SSc research.[191]

One example is the HAQ. While it is a valid measure of physical disability, and is commonly used for patient evaluations, it does not adequately measure psychosocial aspects or other disease-specific impacts in people with SSc.[192] Another common choice is the EQ-5D. Coupled with brevity and ease of interpretation, its good acceptability and construct validity for SSc make it a popular choice for research in this population.[193]

In a large sample of patients with SSc, the EQ-5D's overall mean HRQoL score was 0.66 (SD 0.26); for patients with dcSSc, lower education, shorter disease duration or cardiopulmonary comorbidities, scores were lower.[194] These results raise no questions. Comparing the EQ–5D's results to those of the SF-36, though, discrepancies arise. Over an 8-year follow-up period, as is common with progressive chronic diseases, both the SF-36's mental (MCS) and its physical health component score (PCS) worsened progressively. For the same period, though, the corresponding EQ-5D scores improved. One likely explanation is that although the EQ-5D includes both physical and mental health components, it may lack the sensitivity—particulary regarding the latter—to evaluate SSc-specific impacts on HRQoL.[195]

Chronic condition-specific HRQoL measures that cover both physical and psychosocial health dimensions are fundamental in developing PROMs to evaluate targeted interventions, increase well-being (e.g., to detect need for supportive care), and reduce costs (e.g., via earlier detection of relapses).[26, 196, 197] As the first SSc-specific HRQoL measures, the SScQoL questionnaire was developed and

underwent cross-cultural adaptation according to the five-step procedure prescribed by Beaton et al. (2000), followed, as noted above, by validation in six European countries.[189, 198]

As part of the cross-cultural adaptation process, a local-language translation of the SScQoL was completed by a group of 30 patients in each of the six target countries (Germany, France, Italy, Poland, Spain, Sweden, and the UK).[189] These participants then commented on the items, after which the various versions were sent for psychometric testing using Rasch analysis. Across all countries except one, the findings suggested a seamless adaptation. The exception was Germany, where problems were identified with the dichotomous 'true/not true' response structure in ten items. German patients also indicated a desire for a response structure that would accurately capture a broader range of responses. In the subsequent psychometric testing phase, the problematic items in the German SScQoL revealed significant deviations from the Rasch model, confirming the issues highlighted by patients. This suggested a need to revise the German SScQoL, particularly regarding item wording/presentation, response structure, followed by further psychometric testing.[189]

1.3.2 Patient Assessment of Chronic Illness Care (PACIC)

Up-to-date patient reports on their experience of integrated chronic illness care are essential to the development and evaluation of eHealth-facilitated chronic care models. By identifying both current care practices and unmet patient needs, such reports inform context-specific best practice. This is especially true in rare disease populations, for which evidence and recommendations for clinical management are often scarce.[34, 199]

The Patient Assessment of Chronic Illness Care (PACIC) instrument is a validated questionnaire that assesses patient perceptions relevant to CCM implementation. To capture the patient perspective, it focuses on relevant aspects of patient-centred care and self-management behaviours.[199, 200] The PACIC's 5 subscales address the following domains: 1) patient activation; 2) delivery system design/decision support; 3) goal setting/tailoring; 4) problem solving/contextual counselling; and 5) follow-up/coordination. For all items, response options range from 1 ('never') to 5 ('always'), with higher scores indicating more-integrated patient care.

Prior validation studies in common chronic diseases suggest that the single PACIC score is an appropriate standard measure of chronic care (the overall scale's Cronbach's alpha was 0.93, indicating very high internal consistency); however, various researchers have reported difficulty distinguishing between the instrument's five dimensions.[199, 201, 202] Still, several others have found that PACIC measurements correlate positively with patient outcomes.[203-205] For example, in diabetes, higher PACIC scores are associated with improved glycemic control, self-management activities, and physical activity, as well as diminished distress.[206, 207] And in transplant patients, higher PACIC scores have been positively associated with treatment satisfaction and trust in the transplantation team.[208]

Unlike care models for the above-mentioned common chronic conditions, those for rare diseases typically do not incorporate elements of the CCM.[134-136]. Only recently, responding to a European Organization for Rare Diseases (EURORDIS, a 74-country alliance of 970 rare disease patient organizations) survey using an 11-item PACIC version[95], a large sample of rare disease patients (N=3905) yielded an average score of 2.5 (on a 5-point Likert-type scale ranging from 1='never' to 5='always'). This score indicates healthcare experiences significantly poorer in this group than in others with common chronic conditions.[203, 209-211] For example, in a large metanalysis including 25'942 diabetes patients from 13 countries a pooled PACIC score of 3.0 (95% CI: 2.8-3.2) was found.[210]

In relation to SSc, most potential associations between models of care and patient outcomes (e.g., HRQoL) remain unexplored. However, as the PACIC is a generic instrument, it may not be adequate to address challenges either common to most rare disease care (e.g., lack of treatment options and specialized healthcare resources) or specific to SSc patient needs, e.g., regarding SSc's heterogeneity/severity. Therefore, regarding SSc patient experiences of chronic care dimensions, the PACIC may demand further inquiry via qualitative methods. We recommend qualitative exploration partly to identify additional gaps in SSc patient care and partly to optimize the development of PREMs for this patient group.

1.3.3 eHealth literacy and use

As noted above, general shortages of validated instruments—particularly of PROMs and PREMs focused on eHealth technology and interventions—hinder current efforts to assess and improve eHealth-enhanced integrated care.[183] In rare diseases, this problem is more pronounced: disease-specific quality assessments of eHealth-enhanced integrated care are scarcely available; and little common understanding exists even regarding which measurements should be included.[34] Reflecting such deficits, eHealth applications are commonly developed with little or no understanding of user-centred design, then implemented without contextually adapted strategies.[132, 212] It is scarcely surprising, then, that rates of successful long-term adoption are extremely low.[132]

Among eHealth-facilitated care models, the most successful follow the principles of person-centred care. For example, so that interventionists can help patients build their eHealth literacy, they must empower them, i.e., support them to acquire the knowledge, motivation and competence to *access, understand, appraise* and *apply* relevant information from electronic sources in ways that address or solve their own health problems.[213, 214]

Furthermore, the successful adoption of eHealth applications depends not only on their developers' insights into patients' and healthcare professionals' current attitudes and needs, but also on their ability to adapt to changes in those attitudes and needs.[215] One example of a well-established instrument that succeeded at least partially is the eHealth Literacy Scale (eHEALS), which has been validated in and adapted for several populations and languages.[183, 216] However, four years after its introduction, it remains insufficiently validated for German patient populations (i.e., validated for students and parents) and has not, to our knowledge, been translated into French.[217] Moreover, given the rate of technological advances, its eHealth literacy measures (i.e., eHEALS) no longer adequately cover uses of current technological developments such as social media.[218-220]

Accurate assessment of patients' possession and use of internet-based information and communication technologies (ICTs) and eHealth applications can inform prospective developers regarding how (and how many of) their target populations access, understand, appraise and apply such technologies and services.[168, 221] In SSc care, interventionists will also require a deeper understanding of PROMs and PREMs as tools to evaluate and possibly anticipate advantages and challenges of technology use. To best explore this population's current eHealth use, literacy and needs, we recommend face-to-face qualitative research methods including individual interviews and focus groups.[176]

1.4 Research gap and rationale for this dissertation

Management of any rare disease involves complex challenges. In SSc, high variability in disease presentation and progressively heavy physical and psychosocial symptom burdens make traditional acute care-based care models inadequate.[1, 4, 17] Instead, an integrated chronic care approach—including competent, coordinated multidisciplinary collaboration, as well as self-management support targeting individual patient needs—is recommended.[49, 78, 93, 102] Moreover, the care model should include eHealth technologies, which are highly relevant for geographically dispersed and multisystemic rare diseases. For SSc patients, such technologies would also facilitate accessible, cost-effective and timely patient-provider interactions, as well as tailored behavioural change and self-management interventions.[151, 222]

To date, diverse integrated care initiatives are described and implemented in common chronic diseases.[108, 125, 223] In the context of rare diseases, though, little is known about how the elements of eHealth-facilitated integrated care can most effectively be implemented.[34, 134-136] And although rare disease care pathways are often complex, including large numbers of HPs who need to collaborate and coordinate their strategies and services, few examples guide the development and evaluation of integrated care models to serve their populations. As a result, participatively developed (i.e., by patients and providers together) SSc care models with appropriate contextually-adapted strategies are scarce.[102]

Within the scope of Swiss and international health policy priorities, improving access to high-quality integrated care for people with rare diseases is strongly encouraged.[34, 112] In SSc, the current gap between patient needs and existing care must be bridged. To achieve this objective, the most effective available care models involve person-centred (rather than organization-centred) foci in research and development.[34, 170] To develop and evaluate effective new eHealth-facilitated chronic care models, both patient-reported experiences and outcomes and HPs experiences with care provision, are particularly important, first to understand the current state of care (e.g., contextual factors) then to monitor the new care model's success.

Therefore, the MANagement Of Systemic Sclerosis (MANOSS) study aims to develop a rare disease chronic care model—one based on contextual analysis and stakeholder involvement—focussing specifically on patients living with SSc in Switzerland and their families. In contexts such as this, where empirical evidence is limited (as is often the case with rare disease populations), an in-depth understanding of context, practice patterns and the target audience's needs and barriers is crucial.[35, 224-226] Implementation science provides useful elements first to develop such an understanding, then to support the implementation process.[226]

Several arguments support the need to begin by describing and understand current SSc-specific practice patterns and patient needs, as well as the perspectives of the HPs who care for them within the Swiss healthcare system:

- First, evaluating and developing eHealth-facilitated integrated SSc care will require disease-specific PROMs and PREMs that cover quality of life, chronic care and eHealth literacy/needs. To date, such instruments are either unavailable or lack validation for our specific disease population (i.e., SSc) or language (i.e., German).
- Second, while shortcomings in SSc care and unmet patient needs are internationally well described, SSc-specific chronic care approaches are only partially implemented and include high interregional and international heterogeneity. For this development phase, preparation for future care improvement, adaptation, and reorganization will require early stakeholder involvement. Beginning

with a comprehensive contextual analysis, this involvement will include their input regarding existing chronic care approaches, the patients' and their HPs' care-related experiences, and the patients' and HPs' readiness to use eHealth-facilitated integrated care approaches.

- Third, major challenges arise when eHealth technology is developed without accounting adequately for context-specific and end-user needs. Therefore, from the outset, it is crucial to evaluate SSc patients' and HPs' eHealth literacy and needs. Developing a sustainable eHealth-facilitated SSc care model with appropriate contextually adapted strategies will require extensive eHealth support.

Based on the information and considerations outlined above, this dissertation will contribute to the existing knowledge by exploring and describing the needs of patients living with SSc, as well as by summarizing the perspectives of the HPs who care for them within the Swiss healthcare system. Based on well-established theoretical underpinnings, this systematic participative approach has a strong potential to establish a feasible model of care. Hopefully, it will soon ameliorate the clinical outcomes and mitigate the physical and psychosocial burdens of this marginalized population.

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Chapter 2 Study Aims

Given the gaps in the evidence presented by SSc and rare disease research, the main objective of this thesis was to develop a comprehensive understanding of current chronic illness management and eHealth use in SSc, which would then inform the development of a rare disease chronic care model. This required first the adaptation and validation of certain measurement tools specifically for use with the SSc population, then the formation of relevant stakeholder groups to advise us regarding two mixed-methods studies assessing chronic care and eHealth implementation in the Swiss setting.

The thesis was guided by four primary aims with corresponding sub-aims:

1. To develop a study protocol for contextual analysis and development of a culturally sensitive chronic illness management model for patients with SSc and their families (**Chapter 3**).
2. To improve and validate patient-reported outcome measurements of quality of life, chronic care delivery and eHealth literacy/use for use in SSc.
    a. To review the German Systemic Sclerosis Quality of Life questionnaire (SScQoL), expand its response structure, and examine its scale's content validity, construct validity, unidimensionality, and reliability (**Chapter 4**)
    b. To adapt and validate the 20-item Patient Assessment of Chronic Illness Care (PACIC) for use in SSc (**Chapter 5**)
    c. To adapt other eHealth outcome measurement tools as appropriate for the SSc population and the healthcare professionals who work with them
3. To describe the current state of SSc chronic illness care and quality of life from the patients' perspective—a process that will inform our development of an integrated model of care for SSc (**Chapter 5**)
    a. To evaluate levels of chronic care delivery across the five dimensions measured by the Patient Assessment of Chronic Illness Care (PACIC) scale, alongside quality of life as measured by the Systemic Sclerosis Quality of Life Questionnaire (SScQoL).
    b. To explain patient experience of chronic SSc management along the PACIC dimensions.
4. To describe the eHealth literacy of patients and healthcare professionals as well as perspectives and needs regarding web-based chronic care support (**Chapter 6**).
    a. To assess how SSc patients and professionals access, understand, appraise, and apply web-based health information and technologies to aspects of chronic care.
    b. To deepen our understanding of how, for people with SSc, eHealth literacy, perspectives and needs relate to eHealth use and particularly how they can be incorporated into user-centred eHealth solutions within a new model of care.

Chapter 3 Developing a rare disease chronic care model: Management of systemic sclerosis (MANOSS) study protocol

Agnes Kocher, MScN, RN, Research Assistant, Advanced Practice Nurse [1,2]; Michael Simon PhD, RN, Associate Professor [1,3]; Andrew A. Dwyer PhD, FNP-BC, FNAP, Assistant Professor [4]; Peter M. Villiger MD, Head, Professor [2]; Patrizia Künzler-Heule MScN, RN, Research Assistant, Advanced Practice Nurse [1,5]; Sabina De Geest PhD, RN, FAAN, Professor of Nursing, Director [1,6]; Lut Berben PhD, RN, Advanced Practice Nurse [7,8]; Dunja Nicca PhD, RN, Assistant Professor [1,9]

[1] Institute of Nursing Science (INS), Department Public Health (DPH), Faculty of Medicine, University of Basel, Basel, Switzerland

[2] Department of Rheumatology, Immunology and Allergology, Inselspital Bern University Hospital, Bern, Switzerland

[3] Nursing Research Unit, Inselspital Bern University Hospital, Bern, Switzerland

[4] Connell School of Nursing, Boston College, Chestnut Hill, MA, USA

[5] Department of Gastroenterology/Hepatology and Department of Nursing Development, Cantonal Hospital St. Gallen, St. Gallen, Switzerland

[6] Department of Public Health and Primary Care, Academic Center for Nursing and Midwifery, KU-Leuven, Belgium

[7] Division of Nursing, Department of Medicine, University Hospital Basel, Basel, Switzerland

[8] Department of Nursing Development, University Children's Hospital Basel, Basel, Switzerland

[9] University Hospital Basel, Basel, Switzerland

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3.1 Abstract

Aim

The aim of the Management of Systemic Sclerosis (*MANOSS*) study described in this protocol is to develop a chronic care model, based on a contextual analysis and stakeholder involvement, for patients living with the rare disease systemic sclerosis in Switzerland.

Design

Applying an implementation science approach, this study starts with an explanatory sequential mixed method study for contextual analysis, followed by broad stakeholder involvement for model development and a Delphi study to reach consensus.

Methods

First, a quantitative cross-sectional survey with patients and healthcare professionals will be conducted to identify current practice patterns of chronic illness management and technology readiness. Second, qualitative interviews with patients, family members and healthcare professionals will be performed to gain a deeper understanding of care needs identified in the quantitative survey. Third, a model of care will be co-created with input from patients, healthcare professionals, and other experts. The eHealth enhanced Chronic Care Model will serve as a guiding framework. The new model and corresponding outcome parameters will be refined using a Delphi-study approach to reach consensus on a testable model of care for persons living with systemic sclerosis. The protocol has received ethical approval in September 2018 by the Swiss Ethics Committee.

Discussion

The *MANOSS* study's participatory approach is essential for contextual fit of the model for patients with systemic sclerosis in this setting. Subsequent feasibility testing and implementation are planned to evaluate the model's value in relation to health disparities faced by this patient population.

Impact

Patients living with this rare disease lack access to coordinated, specialized care, and self-management support from qualified healthcare professionals. Reengineering of current care, with consideration for technological opportunities, is warranted to meet patients' and families' needs.

KEYWORDS

Access to healthcare, chronic care model, chronic illness management, eHealth, implementation science, mixed methods, nursing, rare disease, self-management, systemic sclerosis

3.2 Introduction

Systemic sclerosis (SSc) is a rare, multisystemic, autoimmune connective-tissue disease associated with significant morbidity, including multiple organ damage/failure, leading to increased mortality and impaired health-related quality of life.[1, 2] The worldwide prevalence of SSc is estimated to be between 50 and 300 cases per million and around 150 per million in Northern European countries; its incidence is between 3.7 and 23 per million inhabitants.[3, 4]

SSc management differs fundamentally from that of other autoimmune diseases, beginning with the fact that no basic drug treatment exists as different organs and manifestations require different treatment.[1, 5] In fact, certain disease courses do not require treatment, while others lead inevitably to death. Evidence supporting non-pharmacological interventions is limited; and international recommendations for a multi-professional approach are scarce.[6] Major barriers for affected patients include problems with access to SSc-specific care and difficulty finding healthcare professionals (HPs) qualified to support them.[7] Consequently, therapeutic strategies in SSc patients and reasons for referral to specialized HPs vary greatly between countries and centres.[8, 9]

Thus, healthcare systems are challenged to offer comprehensive, disease-specific care that is evidence-based and cost-effective.[10, 11] Implementation science aims to improve clinical practice by combining evidence, stakeholder involvement, theoretical foundations and contextual analysis and using specific

implementation science designs and strategies.[12] Using implementation science to launch novel care models may enable clinicians to better coordinate care and address unmet needs of patients and families.

3.3 Background

Patients with SSc experience a broad range of symptoms. These include various and potentially severe circulatory, dermatological, gastrointestinal, musculoskeletal, pulmonary, and renal disorders.[1] Skin thickening and hardening–skin sclerosis–is very common. Other common symptoms include vasospasms of digital arteries, digital ulcers, lung involvement, esophageal disturbance, fatigue and arthralgia. Physical function is often severely impaired. High levels of disease burden strain mental health, family life and work participation: i.e., health-related quality of life is poor.[13-16]

While SSc can occur at any age, onset is most common between the ages of 45 and 60 years.[3] There is notable gender discordance; 3-4 women are affected for each male case. The reason for this is still unknown. Estimated cumulative 10-year survival is between 56% and 78%, depending on the disease severity.[17] Although the total number of affected SSc patients per country is low, the economic and human burden is high.[18] SSc patients are high utilizers of healthcare resources and have high annual medical costs–particularly those patients with serious disease complications and more functional disability.[19, 20]

Estimated yearly per-patient direct, indirect, and lost productivity costs range from 11,073 Euro in Italy[21] to 18,453 Canadian dollars (12,6006 Euro) in a Canadian sample[22] to 17,365 US dollars (15,4989 Euro) in a large US SSc population[23] to 22,459 Euro in a French cohort of SSc patients.[19]

The SSc-related burden of disease (disability-adjusted life-years, DALYs) has been estimated at 1732 DALYs in 2001 in Spanish SSc patients. This number is based on 562 (32%) years of life lost and 1170 (68%) years lived with disability.[24] Spain's SSc prevalence is 277 cases per million inhabitants.[4]

So far, no epidemiological data are available on the incidence and prevalence of SSc in Switzerland. However, with an estimated prevalence of 150 per million, we can assume that around 1275 persons are living with SSc in Switzerland. Of these, roughly 800 are cared for in university hospitals. Given the variation in SSc patients' clinical courses, it is important to identify the risks and burdens that affect them and society.

3.3.1 Chronic illness management in a rare disease context

Researchers and clinicians working with rare diseases are challenged to conduct clinical studies that would allow the development both of effective therapies and of evidence-based practice.[25] The importance of finding non-pharmacological interventions for SSc and reducing its psychosocial burden is broadly recognized. Patients and their families face major disparities concerning access to and quality of specialized and coordinated healthcare.[7, 9, 26]

A wide variety of therapeutic strategies for SSc exist, including physiotherapeutic interventions and illness-specific therapeutic education.[9] However, access and referral to specialized HPs who can individually tailor these interventions varies widely across European countries and is typically limited to the hospital setting. Furthermore, even in the best-developed healthcare systems, little self-management support is available to patients with inflammatory rheumatic diseases.[27-29]

In many countries, including Switzerland, most patients with SSc are cared for by non-specialized HPs with little or no experience with SSc. These clinicians report substantial SSc-related educational needs.[9]

As a result, patients typically receive limited disease-specific therapeutic education and are often left to cope with their illness and its consequences on their own.[27, 30, 31] And whereas some join peer-led support groups, others cite various reasons (e.g., lack of feasibility, negative beliefs or lack of awareness about support groups) for not participating in such groups.[32] Thus, patients' and their families' SSc self-management is an essential task to guarantee favourable health outcomes.[33]

Alongside a reshaping of ambulatory care, self-management support is essential to comprehensive chronic care.[34-36] Its primary aim is to strengthen individuals' skills and confidence in managing their health and adapting to their conditions' physical and psychosocial consequences for improved quality of life.[33] The most effective self-management programs are integrated into comprehensive strategies incorporating multidisciplinary care teams with close collaboration between members, coordinated care and patient-centred communication.[35, 37, 38] For rare and complex diseases, self-management support should be highly individualized, flexible and tailored to respond to varied disease and symptom representations.[39, 40]

Several studies have investigated SSc patients' informational and educational needs and available education programs.[30, 41-43] However, only one has developed and evaluated a structured SSc self-management program that does not require participants to travel to a centralized location. This program was first delivered in print format by mail[44] and later transitioned to an interactive web-based format.[45]

The patients who used the print version (n=49) showed significant improvements in self-efficacy for managing pain[44], while those using the web-based program (n=16) showed increased ability for managing care, as well as decreased fatigue and depressive symptoms[45]. An updated program including new treatment strategies produced no statistically significant differences between its users (n=267) and a group using *The Scleroderma Book: A Guide for Patients and Families* regarding symptom self-management self-efficacy and secondary outcomes.[46, 47]

Research across other chronic conditions has shown that the success of chronic illness management interventions and web-based technology depends on the acceptance of both patients and HPs.[48-50]

3.3.2 Web-based technologies

Web-based technologies, also known as eHealth, use various modes of information and communication to connect patients and clinicians regardless of the distance between them.[51-53] Increasingly, HPs are employing eHealth approaches to disseminate health information and support self-management, decision-making, and behavioural change. Favourable outcomes have been shown across a variety of chronic conditions.

Where rare and complex diseases are concerned, eHealth can ameliorate some health equity issues via improved access and reduced patient travel requirements.[54, 55] Van der Vaart *et al.*[56] found that Dutch SSc patients viewed the use of internet technology in their treatment more favourably than those with rheumatoid arthritis–especially for e-consultations and peer support forums. However, computer use may pose problems for SSc patients with limited finger flexibility.[57] Another recent study from the Netherlands found that patients and HPs desired an informational website to serve the needs of both groups.[58] The authors highlighted the importance of shared care/multidisciplinary collaboration, medical data exchange, information for patients and HPs, patient empowerment, and non-pharmacological approaches for SSc.[58] These recommendations are in line with the Chronic Care Model and support our strategy of including eHealth in an SSc care model.[51]

3.3.3 Theoretical framework: eHealth enhanced Chronic Care Model

We plan to use the eHealth enhanced Chronic Care Model as a framework to guide the design and evaluation of a new care model for SSc patients.[51] Originally developed by Wagner[36], this model is built on an evidence-based framework for improving chronic illness care. It is based on the primary assumption that improving patient outcomes demands a multifaceted approach incorporating patient, provider and system level interventions. System level interventions include six modifiable components of healthcare delivery: organizational support, clinical information systems, delivery system design, decision support, self-management support, and community resources. One or more of these components can be modified to improve care processes and patient outcomes.[59]

Furthermore, the eHealth enhanced Chronic Care Model includes electronic models for symptom monitoring, eHealth education and support[51], all of which are highly relevant for geographically dispersed rare diseases. Technology-based interventions are feasible options for accessible, cost-effective and timely patient-provider interactions, as well as for tailored behavioural change interventions.[60, 61] However, major challenges arise where eHealth technology is developed without user-centred design and implemented without appropriate contextually adapted strategies.[62]

3.3.4 Significance of the proposed study

We aim to incorporate elements of the Chronic Care Model and web-based technology in ways that will improve access to SSc care and support from qualified HPs knowledgeable in SSc. Ultimately, we believe this will lighten the individual and social burdens of SSc. Within the scope of the Swiss "Gesundheit 2020" health policy priorities, this strategy is strongly encouraged as a means of improving access to high-quality care for people with rare diseases.[63] When empirical evidence is limited (as is often the case with rare disease populations), an implementation science approach including in-depth understanding of context, practice patterns and the target audience's needs and barriers is crucial.[10, 48, 64, 65] This participative and systematic approach has strong potential to establish a feasible model of care that will ameliorate the clinical outcomes and mitigate financial strains of this marginalized population.

3.4 The study

3.4.1 Aims

The overall aim of the Management of Systemic Sclerosis (*MANOSS*) study is to develop a measurable model of chronic care for patients living with SSc in the French- and German-speaking parts of Switzerland. To facilitate future implementation, the model will draw on regional contextual knowledge and the involvement of three stakeholder groups: SSc patients, their families, and the HPs who help them manage their conditions. Figure 1 depicts the *MANOSS* study and the specific aims of the study. In addition to phase-specific aims, one superordinate aim covers the first two interrelated study phases, with a second covering phases 3 and 4:

- To examine relevant aspects and resources for chronic illness management in patients with SSc.
- Phase 1: A quantitative study is planned to evaluate current practice patterns of SSc care and to map their relationship to basic elements of chronic care (Aims 1-3).
- Phase 2: A qualitative study will be conducted to explore current practice patterns in depth and elicit experiences and needs of patients with SSc, their families, and HPs (Aims 4-6).

- To develop a culturally sensitive chronic illness management model for patients with SSc and their families.
- Phase 3: Drafting the new model of care using expert groups including all stakeholders.
- Phase 4: A Delphi study will be used to reach consensus on the new chronic illness management model (Aim 7).

3.4.2 Design / Methodology

This protocol describes the first phase of a larger implementation science project to develop a new model of care for SSc in Switzerland. Implementation science focuses on effectively introducing solutions into practice (i.e. novel care models into health systems).[12, 65] Successful implementation into real-world settings demands comprehensive context analysis and broad stakeholder involvement. We will employ an explanatory, sequential mixed methods design for contextual analysis of factors at the individual and organization levels.[66] We will engage key stakeholders throughout the development process and will conduct a Delphi study[67] to develop a consensus-based SSc care model adapted to a Swiss context (see overview, Figure 1).

3.4.3 MANOSS explanatory sequential mixed methods study

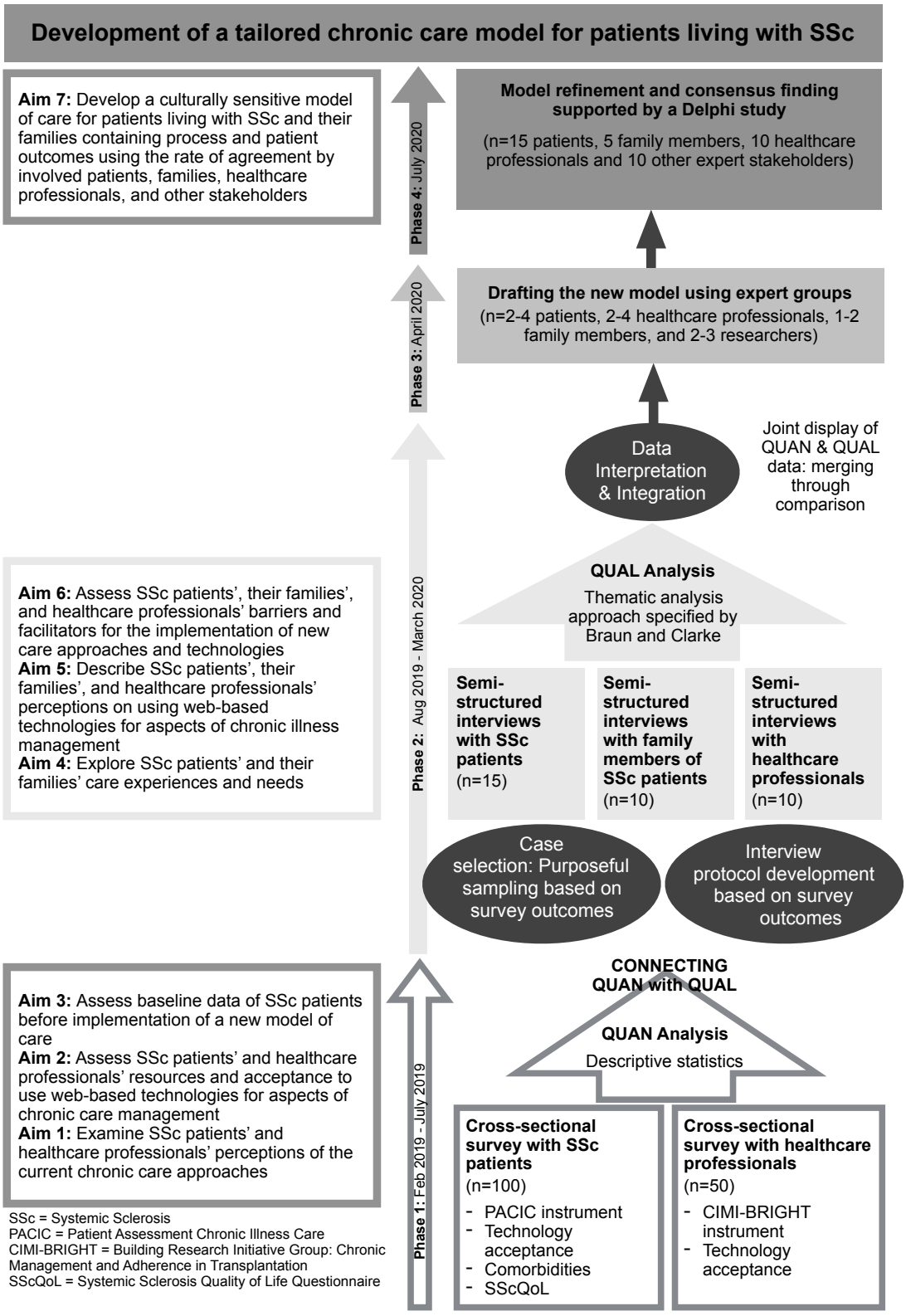
Phase 1: MANOSS cross-sectional quantitative survey

Recruitment and sampling

We will use a convenience sample of 100 patients living with SSc and 50 HPs from the French- and German-speaking parts of Switzerland. For pragmatic reasons, we will not rely on a population-based, representative Swiss sample (e.g., Italian-speaking Swiss will not be included). To include data and perspectives spanning a range of disease severity and care experiences, patients will be recruited from university and cantonal (state) hospitals, as well as from rheumatology outpatient clinics. Formal recruitment will be supplemented by engaging patient communities including the Swiss and cantonal leagues against rheumatism and the Swiss scleroderma patients' association. Adult patients (>18 years) with SSc diagnoses, receiving care in the Swiss healthcare system, and understanding German or French will be included.

As HPs have varying levels of knowledge and experience in SSc care, in addition to outpatient rheumatologists and HPs, we aim to actively recruit professionals from university and cantonal (state) hospitals. HPs–including registered nurses, occupational therapists, physiotherapists, and medical doctors–who work in Switzerland, understand German or French, and see at least one SSc patient per year will be surveyed. Those with less than six months' experience with SSc patients will be excluded.

Figure 1. Management of Systemic Sclerosis study overview: Mixed methods and Delphi study



SSc = Systemic Sclerosis
PACIC = Patient Assessment Chronic Illness Care
CIMI-BRIGHT = Building Research Initiative Group: Chronic Management and Adherence in Transplantation
SScQoL = Systemic Sclerosis Quality of Life Questionnaire

Data collection

To assess various dimensions of chronic care, technology acceptance, and patients' health, we have adapted a number of selected questionnaires (**Table 1**). First, we cross-checked questionnaires between German, French and original English versions of candidate instruments at the item level. Second, following the International Society for Pharmaco-economics and Outcomes Research (ISPOR) guideline for translation and cultural adaptation[68], we adapted all chosen items as necessary to fit SSc patients' and Switzerland's healthcare context. Questionnaires not available in French or German were translated by professional translators as per Wild et al.[68], using forward-backward translation. To identify discrepancies in adaptation and translation, questionnaires were pre-tested in a small group of patients and HPs.

While paper questionnaires will be distributed via normal post, participants can also complete the survey online via the quality assured EvaSys® software. Both the paper and web-based versions require approximately 30 minutes to complete: there are 142 items for patients and 102 for HPs. The outcomes, the corresponding questionnaires, and the necessary adaptations are listed in **Table 1** (below).

Patient perspectives on chronic illness care: We will use the 26-item Patient Assessment of Chronic Illness Care (PACIC+) instrument [69], which adds 6 items assessing behavioural change to the PACIC's original 20.[70, 71] Items are derived from the "5A" framework (ask, advise, agree, assist, and arrange) and a patient-centred model of behavioural counselling. This framework is widely used to enhance self-management support and links to community sources–two key components of the Chronic Care Model.[71, 72]

Healthcare professional perspectives on chronic illness management: Regardless of the chronic disease population, integrated care for chronic conditions plays an important role in improving outcomes for affected patients.[35] Therefore, we will gather data on HPs' viewpoints via an adapted version of the 52-item Chronic Illness Management Implementation–Building Research Initiative Group: Chronic Management and Adherence in Transplantation (CIMI-BRIGHT) instrument.[73] It was originally developed to assess chronic illness management implemented in organ transplantation programs using the Innovative Care for Chronic Conditions (ICCC) framework.[35] We adapted our version culturally to reflect SSc care and the Swiss healthcare system (**Table 1**). We also developed and added an item assessing the multi-professional SSc care teams.

Acceptance of technology and eHealth services: As services are often not available within convenient distances, eHealth technology can play a considerable role in care delivery for patients with rare diseases. Therefore, we will assess patients' technology-related experience and skills using 37 items from a questionnaire developed for use in organ transplantation by Vanhoof et al.[50]. We also incorporated 19 items from an eHealth literacy and service survey aimed at cancer patients.[74] In total, the questionnaire contains 66 items.

HPs will answer a brief assessment based on the work of Vanhoof et al.[50] and Halwas et al.[74] Their 33-item questionnaire measures acceptance of web-based technology (e.g., sharing health data or communicating with patients online).

Health information: Patients will be asked to provide information on their condition and SSc subtype as well as comorbidities. Comorbidities will be assessed using the 12-item Self-Administered Comorbidity Questionnaire (SCQ).[75] The 29-item Systemic Sclerosis Quality of Life Questionnaire (SScQoL) will be used to measure health-related quality of life.[76] This assesses four domains of interest: emotion, physical

adaptation, and impact on self/others. The adapted French and German versions use a 4-point response scale (**Table 1**).

Data analysis

Descriptive statistics (e.g., frequency distribution, percentage, mean, median, standard deviation, range, bivariate associations) will be used to summarize quantitative data and to describe socio-demographic characteristics. PACIC, CIMI-BRIGHT, and technology acceptance ratings will be analysed separately using R, Version 3.4.1 (2017-06-30) to evaluate continuity of care, self-management support and technology use in existing Swiss care models for patients with SSc. Overall PACIC and CIMI-BRIGHT scores, frequency distributions, means, and standard deviations will be calculated. We will compute 95% confidence intervals of means/percentages. Based on quantitative results, we will formulate hypotheses/assumptions to further explore these results using in-depth qualitative interviews. The tentative interview guide (**Table 2**) will be tailored to fit our assumptions or conflicting survey results.

Phase 2: MANOSS qualitative interviews

Recruitment and sampling

Purposeful sampling with a maximum variation strategy will be employed to include 10-15 patients, family members and HPs to answer questions based on the results of Phase 1 (e.g., reasons for technology-use and non-use). In qualitative research, this sample size is usually adequate to reach saturation, i.e., the point in data collection and analysis when new information produces little or no change to the codebook.[77, 78] Maximum variation in the patient sample enables the integration of those with diverse experiences due to socio-demographic characteristics (e.g., age, gender, education), disease duration, and care settings. For our sample of HPs, we will select participants with varied professional backgrounds, experience and socio-demographic characteristics.

Data collection

Individual semi-structured interviews[79] will be used to explore the needs and care experiences of patients, family members, and HPs, as well as their readiness to use new technologies and approaches to care. Recorded interviews will be transcribed verbatim. Concurrent analysis will allow the incorporation of new topics raised by participants into subsequent interviews (see interview guide, **Table 2**).

Data analysis

Qualitative interview data from the three stakeholder groups will be systematically analysed at the level of each group using the thematic analysis techniques described by Braun and Clarke.[80] Briefly, this iterative technique will be used to inductively identify meaningful patterns (themes) that reflect commonalities and differences between patients' and HPs' viewpoints concerning their approaches to chronic SSc care. We will use qualitative data management software (MAXQDA, http://www.maxqda.com) to analyse and structure interview data. The results regarding each of the stakeholder groups will be combined to create comprehensive statements about SSc-related perspectives and chronic illness management needs.

Mixed methods data integration

Quantitative and qualitative data will be analysed separately and integrated at the level of data interpretation.[66] Data interpretation will be presented in joint displays that target areas of patient care where improvement is possible and will inform model development. This process will be supported by two patients and two HPs each.

Table 1. Overview of measurements in the MANOSS cross-sectional survey

Patient perspectives on chronic illness care			
Dimensions	**Original instrument**	**Instrument characteristics (original instrument)**	**Instrument adaptations**
Alignment of care with the specifications of the Chronic Care Model. Covering the key components of the Chronic Care Model and the 5As (ask, advise, agree, assist, and arrange) according to the patient-centered model of behavioral counseling: 1. Patient activation 2. Delivery system design/ decision support 3. Goal setting 4. Problem-solving/ contextual counselling 5. Follow-up/ coordination 6. 5As	Patient Assessment Chronic Illness Care (PACIC) 20-item instrument with additional six 5A items *English version*: (Glasgow, Wagner et al. 2005, Glasgow, Whitesides et al. 2005) *German version*: (Rosemann, Laux et al. 2007) *French version*: IUMSP, CHUV and University of Lausanne, August 2011 (Iglesias et al. 2014) Translations can be found here: http://www.improvingchroniccare.org/index.php?p=Translations&s=360	Response options: 5-point scale ranging from "1" ("never") to full accordance "5" ("always") Number of items: 26 (PACIC and six 5A items) Psychometric evidence: Validated in several languages and settings and tested in patients presenting diverse chronic diseases (Schmittdiel, Mosen et al. 2008, Goetz, Freund et al. 2012, Rick, Rowe et al. 2012, Iglesias, Burnand et al. 2014). *Original English version*: Internal consistency: Cronbach's alpha 0.93. Test-retest reliability r = 0.58 (during the course of 3 months) (Glasgow, Wagner et al. 2005). *German version*: Internal consistency ranging from 0.52 to 0.97 for Pearson's r, Cronbach's alpha 0.78. Test-retest reliability (intraclass correlation coefficient) exceeded 0.77 (Rosemann, Laux et al. 2007). *Original French version*: Validation study conducted in the French part of Switzerland tested all published validation models using confirmatory factor analysis (Iglesias, Burnand et al. 2014). The only model showing acceptable fit was the 11-item single-dimension model. The original 20-item instrument showed acceptable model fit in previous studies, but not in that of Iglesias et al. Scoring: Single score (unidimensional). Higher scores correspond with a higher alignment of care with the Chronic Care Model (Iglesias, Burnand et al. 2014).	Response options: No changes Number of items: 26 Revision of items: *German version*: 22 items adapted to population and setting *French version*: 21 items adapted to population and setting

Healthcare professional perspectives on chronic illness management (I)			
Dimensions	**Original instrument**	**Instrument characteristics (original instrument)**	**Instrument adaptations**
Practice patterns relating to chronic illness management. Covering the 5 building blocks of the Innovative Care for Chronic Conditions framework (ICCC): 1. Provide continuity and coordination 2. Encourage quality through leadership and incentives 3. Organize and equip healthcare teams 4. Support self-management and prevention 5. Use of information systems	Chronic Illness Management Implementation–Building Research Initiative Group: Chronic Management and Adherence in Transplantation (CIMI-BRIGHT) instrument (Berben, Russell et al. 2014)	Response options: 4-point scale ranging from "1" ("strongly disagree") to "4" ("strongly agree"); and "5" ("don't know"; set to missing) Number of items: 52 Psychometric evidence: *Original English version:* Content validity: 0.86. Interrater reliability pilot tested: ranging between 75% and 85%. Internal consistency: Cronbach's alpha 0.94 (Berben, Russell et al. 2014). *German and French version:* No further information on psychometric properties of the German and French version available at current time. Scoring: Average score (unidimensional), with higher scores corresponding with higher levels of chronic illness management implemented.	Response options: No changes Number of items: 45 Revision of items: 44 items adapted to population and setting
Preparedness of the team in view of chronic illness management. Refers to the skills and availability of equipment or tools to facilitate chronic care.	CIMI-BRIGHT questionnaire to assess preparedness of the transplant team in view of chronic illness management (Nuno, Coleman et al. 2012, Denhaerynck, Berben et al. 2018).	Response options: 4-point scale ranging from "1" ("strongly disagree") to "4" ("strongly agree"); and "5" ("don't know"; set to missing) Number of items: 10 Psychometric evidence: *Original English version:* 5 of the original 10 items retained in a unidimensional scale, with a Cronbach's alpha of 0.82 (Denhaerynck, Berben et al. 2018). *German and French version:* No further information available. Scoring: Average score (unidimensional), with higher scores reflecting higher level of preparedness.	Response options: No changes Number of items: 3 Revision of items: 3 items adapted to population and setting

Healthcare professional perspectives on chronic illness management (II)			
Dimensions	**Original instrument**	**Instrument characteristics (original instrument)**	**Instrument adaptations**
Core competencies of the team in view of taking care of chronically ill patients: • Patient-centered care • Partnering • Quality improvement • Information and communication technology • Public health perspective	CIMI-BRIGHT questionnaire to assess core competencies (Berben, Denhaerynck et al. 2015, Denhaerynck, Berben et al. 2018)	Response options: 4-point scale ranging from "1" ("strongly disagree") to "4" ("strongly agree"); and "5" ("don't know"; set to missing) Number of items: 24 Psychometric evidence: *Original English version:* Internal consistency: Cronbach's alpha 0.96 (Berben, Denhaerynck et al. 2015). *German and French version:* No further information available. Scoring: Average score (unidimensional), with higher scores reflecting a higher degree of core competencies.	Response options: No changes Number of items: 11 Revision of items: 9 items adapted to population and setting
Description of the multi-professional team for the care of people with SSc	Investigator-developed	Response options: Doctors, occupational therapists, physiotherapists, registered nurses, medical/ nursing assistants, social workers, psychologists, others, there is no team, don't know (multiple answers possible) Number of items: 1	

Acceptance of technology and eHealth services (I)			
Dimensions	**Original instrument**	**Instrument characteristics (original instrument)**	**Instrument adaptations**
Possession of new technologies and electronic devices	Technology acceptance questionnaire developed for organ transplant patients by Vanhoof et al. (2017): Possession and use of modern information and communication technologies	Response options: Cell phone, smartphone, tablet, portable computer (laptop), desktop computer, or SmartWatch (yes/no) Access to and type of Internet (wired-wireless-mobile) Number of items: 37 Psychometric evidence: No information on psychometric properties, validation work in progress Scoring: On item level. Higher scores correspond with higher level of technology acceptance.	**Questionnaire for patients** Response options: Do you own one or more of the listed devices? Cell phone, smartphone, tablet, portable computer (laptop), desktop computer, or SmartWatch (yes/no), Access to Internet (yes/no), Type of Internet subscription (e.g., Internet subscription at home with a download speed of >50.0 Mbit per second) Number of items: 8 Revision of items: 2 items adapted **Questionnaire for healthcare professionals (HPs)** Response options: Do you use one or more of the listed devices for your daily work? Cell phone, smartphone, tablet, portable computer (laptop), desktop computer, or SmartWatch (yes/no) Number of items: 6 Revision of items: 0 items adapted
Skills and knowledge concerning new technologies (I)	Technology acceptance questionnaire developed for organ transplant patients by Vanhoof et al. (2017): Possession and use of modern information and communication technologies	Response options: Frequency of using modern information and communication technologies: never, less than once a week, multiple times a week, every day, multiple times a day, and, if applicable, reasons for non-use. Number of items: 37 Psychometric evidence: No information on psychometric properties Scoring: On item level. Higher scores correspond with higher level of technology acceptance.	**Questionnaire for patients** Response options: Frequency of using Internet for different purposes (e.g., sending and/or receiving emails): never, several times a year, several times a month, several times week, daily Number of items: 19 Revision of items: 4 items adapted, 1 investigator-developed item **Questionnaire for HPs** Response options: Frequency of using Internet for different purposes (e.g., sending and/or receiving emails (never, several times a year, several times a month, several times week, daily) Number of items: 7 Revision of items: 3 items adapted, 2 investigator-developed items

Acceptance of technology and eHealth services (II)			
Dimensions	**Original instrument**	**Instrument characteristics (original instrument)**	**Instrument adaptations**
Skills and knowledge concerning new technologies (II)	Usage of eHealth services questionnaire (Halwas, Griebel et al. 2017)	Response options: Frequency of using eHealth services: I use them regularly, I use them from time to time, I have already used them once, I would use them but I have not yet, they are out of the question for me. Number of items: 14 Psychometric evidence: *Original German version:* No information on psychometric properties available (Halwas, Griebel et al. 2017) Scoring: On item level. Higher scores correspond with higher-level eHealth service usage.	**Questionnaire for patients** Response options: Frequency of using Internet for different purposes (e.g., for email contact with a physician or other healthcare professional (never, several times a year, several times a month, several times week, daily) Number of items: 11 Revision of items: 5 items adapted **Questionnaire for HPs** Response options: Frequency of using Internet for different purposes (e.g., for email contact with patients (never, several times a year, several times a month, several times week, daily) Number of items: 4 Revision of items: 4 items adapted
eHealth literacy	Assessment of eHealth literacy (Halwas, Griebel et al. 2017)	Response options: Likert scale ranging from "1" ("I totally disagree") to "10" ("I totally agree"), including the possibility to choose 'I have not used health related Internet offers yet' Number of items: 8 Psychometric evidence: *Original German version:* Internal consistency: Cronbach's alpha 0.851 (Halwas, Griebel et al. 2017) Scoring: On item level. Higher scores correspond with a higher level of eHealth literacy.	**Questionnaire for patients** Response options: 10-point Likert scale ranging from "1 ("not at all") to "10" ("I fully agree") Number of items: 8 Revision of items: 4 items adapted **Questionnaire for HPs** Response options: 10-point Likert scale ranging from "1 ("not at all") to "10" ("I fully agree") Number of items: 5 Revision of items: 4 items adapted
Readiness and motivation to use new technologies	Technology acceptance questionnaire developed for organ transplant patients by Vanhoof et al. (2017): Patients' views on potential interactive health technology features	Response options: To what extent would you see yourself using a range of common health technology features: certainly not, neutral, certainly Number of items: 37 Psychometric evidence: No information on psychometric properties, validation work in progress Scoring: On item level. Higher scores correspond with a higher level of readiness to use technologies.	**Questionnaire for patients** Response options: 'not at all'; 'not true'; 'neither'; 'applies'; 'fully true' or Likert scale ranging from "1" ('not at all important') to "10" ('very important') or Likert scale ranging from "1" ('no interest at all') to "10" ('very big interest') Number of items: 19 Revision of items: 4 items adapted, 5 investigator-developed items added **Questionnaire for HPs** Response options: Likert scale ranging from "0" ('no interest at all') to "10" ('very big interest') Number of items: 17 Revision of items: 10 items adapted, 4 investigator-developed items added

Health information			
Dimensions	**Original instrument**	**Instrument characteristics (original instrument)**	**Instrument adaptations**
Health-related quality of life: Impact of SSc on health and well-being: • Emotion • Physical adaptation • Impact on/ with others • Impact on self	Systemic sclerosis quality of life (SScQoL) questionnaire (Ndosi, Alcacer-Pitarch et al. 2018)	Response options: Dichotomous (yes/no) responses Number of items: 29 Psychometric evidence: Translated into six languages and validated in a cross-sectional study involving 1080 patients from seven European countries (Ndosi, Alcacer-Pitarch et al. 2018). All translations, except the German version, demonstrated measurement equivalence and fit to the Rasch model. German patients reported difficulties with some dichotomous answer options. Test-retest reliability: 0.94 Scoring: Coded as 1 (yes) and 0 (no). Each item contributes to the total score and five subscale measures for function (6 items), emotional (13 items), sleep (2 items), social (6 items), pain (2 items). Subscale score provides the estimate of quality of life specific for that domain. Higher total score indicates a worse quality of life.	Response options: 4-point response option was integrated for all items for the German and the French version (3=all the time; 2=most times; 1=sometimes; 0=never) Number of items: No changes Revision of items: *German version*: 13 items adapted; *French version*: 15 items adapted
SSc information: • SSc subtype • Number of years living with SSc	Investigator-developed	Response options: Limited SSc, diffuse SSc, undifferentiated form of SSc, don't know, years living with SSc Number of items: 2	
Comorbidities	Self-Administered Comorbidity Questionnaire, SCQ (Sangha, Stucki et al. 2003)	Response options: Do you have the problem? (yes/no) Do you receive medication for it? (yes/no) Does it limit your activities (yes/no) Number of items: 12-15 (12 defined medical problems and 3 optional open-ended items for other conditions) Psychometric evidence: Construct validity, measured by the correlation between SCQ and Charlson Comorbidity Index (CCI), was moderate (0.55). Test-retest reliability (intraclass correlation coefficient): 0.94 (95% CI 0.72-0.99). Criterion validity was measured by correlation of SCQ to SF-36 and was fair to moderate (from r=0.03 to 0.39), depending on SF-36 subscale (Sangha, Stucki et al. 2003, Molto and Dougados 2014). Scoring: Maximum of 3 points for each medical condition: 1 point for the presence of the problem, another point if he/she receives treatment for it, and an additional point if the problem causes a limitation in functioning. Maximum score totals 45 points if the open-ended items are used and 36 points if only the close-ended items are used.	Response options: No changes Number of items: No changes Revision of items: No changes
Demographics			
Dimensions	**Original instrument**	**Instrument characteristics (original instrument)**	**Instrument adaptations**
Patients' demographics	Investigator-developed	Response options: Year of birth, gender, marital status, living status, employment Number of items: 5	
Healthcare professionals' demographics	Investigator-developed	Response options: Year of birth, gender, current position (e.g., staff nurse, advanced practice nurse, rheumatologist, general practitioner, physiotherapist, occupational therapist, social worker, psychologist), years of practicing as healthcare professional, years spent practicing in rheumatology, number of SSc patients seen per year, percentage of work spent looking after SSc patients, main field of daily work (e.g., clinical in university clinic, clinical in non-university clinic, clinical in private practice, clinical in rehabilitation clinic, research), attendance of SSc-specific training courses (e.g., EULAR course) Number of items: 9	

Table 2. Questions for interviews with patients, family members and healthcare professionals

Patients and family members (individually)

First part	
Key questions	***In-depth questions***
1. Can you tell me how you experience your/your family member's professional care?	- If you remember the time of the diagnosis, can you tell me how you were informed about the disease and its effects? - How did you find out about the various offers? - How did you experience the support provided by the various specialists and professions? - What did you experience as supportive? - Where did you lack support? - If you remember the last year, can you tell me how you experienced your/your family member's everyday life with systemic sclerosis? - Can you tell me about your experiences managing a chronic and rare disease? - What difficulties were you confronted with?
2. If you imagine your future, can you tell me what the best care would be for you and your family members?	- What new technologies, such as Internet consulting, would you like to use? - What do you know about such offers? - What support would you hope to get from such new services? - Can you imagine using such new offers in the future (e.g., an online training program for systemic sclerosis patients)? - What would be decisive for the use of new technologies? - What concerns do you have? - How should your family be involved? - What about (online) contact with other people living with systemic sclerosis?
Second part This second part of the interview will contain specific questions related to the answers given by the participants in the quantitative cross-sectional survey.	

Healthcare professionals

First part	
Key questions	***In-depth questions***
1. If you remember the last year of your clinical practice, can you tell me how you experienced the management of systemic sclerosis patients?	- If you remember the newly diagnosed systemic sclerosis patients, can you tell me how they were informed about the disease and its effects? - Can you tell me about your experiences managing a chronic and rare disease? - What difficulties were you confronted with? - What did you experience as supportive? - Where did you lack support? - How did you experience the support provided by the various specialists/professionals? - Which offers or professionals did you involve/work with? - How did you find out about the various offers and responsibilities of other professionals/specialists?
2. If you imagine the future, can you tell me what the best care/management of systemic sclerosis would be for you as a professional?	- What (new) technologies would you like to use (e.g., individual online consulting, online platform to educate a group of patients) - What do you know about such (new) offers/services? - What support would you hope to get from such (new) offers/services? - Can you imagine using such (new) offers/services in the future (for example an online training program for systemic sclerosis patients)? - What would be decisive for the use of new technologies? - What concerns do you have? - How should the patient's family be involved? - What about (online) peer support of systemic sclerosis patients?
Second part This second part of the interview will contain specific questions related to the answers given by the participants in the quantitative cross-sectional survey.	

3.4.4 MANOSS Delphi study

Phase 3: Model development using expert groups

This phase will begin with the selection of two approximately-diverse expert groups–one French-speaking and one German-speaking–of 4-6 participants each. Stakeholder groups will include patients (n=2-4), HPs (n=2-4), family members (n=1-2), and researchers with expertise in implementation science (n=2-3). The groups will meet twice. In the first meeting, the group will create a logic model of the problem (based on data from phase 1 and 2). Key impact points will be identified and defined. In the second meeting, the logic model will be mapped onto the Theory of Change (TOC) to chart map pathways of anticipated change with possible interventions and outcomes. Implementation barriers and facilitators will be considered and discussed. The final product will be a TOC plan created by key stakeholders.

Importantly, TOCs have been particularly successful for implementing complex intervention programs[81]; and expert groups are an established method to inform Delphi studies.[82] Together with the Theory of Change approach, their use facilitates and channels critical thinking through the processes of defining primary care needs and measurements, discussing conflicting data and ideas, and planning and agreeing on the purpose of the model.

Phase 4: Model refinement and consensus finding supported by a Delphi study

Recruitment and sampling

Group sizes of Delphi panels vary widely[67] with larger groups recommended for heterogeneous groups (as in this project). We will invite approximately 15 patients, 5 relatives, 10 HPs and 10 other expert stakeholders (e.g., clinical leaders, economists, insurers, politicians, computer scientists) to participate in the Delphi study. These panels will be drawn neither from participants in Phase 2 nor from the expert groups.

Data collection and analysis

Participants will be asked to rate the relevance, clarity, and applicability of the proposed items of the model using a 10-point scale (1= not at all relevant/ clear/ applicable, 10 = very important/ clear/ applicable). Additionally, participants will be given the opportunity to respond using open text. Participants will be invited via email to participate using EvaSys. For those unable to or not willing to participate electronically, a paper version will be provided.

After each round, ratings will be analysed to determine items to be either dropped or combined for subsequent rounds until consensus is reached. Consensus will be defined as a median score of ≥ 7 by 70% of participants for 80% of the items. The ultimate aim of the Delphi study will be to describe the culturally sensitive, patient-centred chronic illness management model for patients with SSc and their families.

3.4.5 Ethical considerations

The responsible Swiss ethics committee approved this study in September 2018 (EKNZ 2018-01206). Patient information forms and informed consent documents comply with that committee's templates. All participants will receive a full written explanation of the purpose of the study, the voluntary nature of their participation and the use of their contributions.

3.4.6 Validity and reliability

Triangulation of several research methods and the involvement of multiple data sources, multiple sites, and multiple stakeholder perspectives will help to provide a broad and contextualized image of the research topic, thus promoting credibility.[83] Where possible, validated or pre-tested tools will be used for quantitative data collection. Due to limited availability of validated tools for specific rare disease groups, most of questionnaires used have been adapted for SSc. However, combined with the triangulation of multiple methods and perspectives, our use of an established adaptation approach will help reduce potential bias.[68] The patient questionnaire was pilot-tested involving three patients, four rheumatology nurses and three researchers. Questionnaires for HPs were pilot-tested with one patient, four rheumatology HPs and three researchers.

Regarding qualitative data collection, each analytical step will be critically discussed by the research team. To ensure the accuracy of our validation measures, we will also employ a structured 15-item checklist developed by Brown and Clarke.[80]

As views of certain individuals often dominate expert group discussions, we will use the Delphi technique whereby participants do not interact directly and all responses are given equal weight.[84] And as participants will shape the final model, the Delphi study will also help ensure valid results.

3.5 Discussion

Today, chronic illness management strategies remain little better-established for patients with SSc than they were in 2012.[11, 85] While the full range of barriers to sufficient chronic illness management in Switzerland remains unclear at the organizational level, some institutions still refuse, for various reasons, to share their data with others; and financial, personal, or other incentives to improve chronic care have little more traction today than when Lauvergeon et al.[85] observed this problem seven years ago.

We presume that financial and motivational barriers affect both HPs and patients. However, the particular nature and extend of those barriers are poorly understood.[48] Our project has a strong focus on understanding the contexts of SSc patients and HPs in Switzerland. This knowledge is essential to determine needs/barriers to implementing new chronic illness management strategies and web-based technology.

It is also vital to understand, as fully as possible, the acceptability and feasibility of the various elements of any planned interventions well in advance of implementation.[59] We can help ensure these by involving patients at various disease stages, severity and trajectories, across multiple settings, and language regions, as well as HPs from diverse disciplines with a broad range of skills and experiences.

For successful implementation, the model must be equitable and suitable both for people living with SSc or for those caring for them. Concerning the use of technology, there is little clear evidence that, with rare conditions, access to information and the anonymity afforded by the internet can facilitate self-management.[54] In this sense, eHealth has expanded the reach of care for patients with rare diseases in extremely important ways. This project will tackle the problem of optimizing the blend of eHealth and

direct, face-to-face care. Also, wherever possible, we will employ multiple approaches to overcome education and literacy barriers to encourage broad participation and uptake.

In the context of a rare disease, this study protocol provides an example of stakeholder involvement to develop a complex intervention based on literature, theory, and patient priorities.[86] To overcome the sparseness of the evidence base–a common limitation in rare disease research–we will combine multiple methods to gain a comprehensive picture of SSc patients' and their caregivers' needs, preferences regarding web-based technology and barriers to improving their practices. This and other combined approaches will inform the subsequent evaluation of the resulting complex chronic illness management intervention. Concerning the outcomes, patient feedback will help guide HPs, healthcare managers and policy-makers regarding the intervention's effectiveness and the success of our implementation strategy.[64, 87] This serves as an example how a clear understanding of the target context is not only advantageous but essential to an effective implementation. Future steps will include plans to test feasibility and the setting's readiness to adopt the new model of care.

3.5.1 Limitations

The *MANOSS* study will be subject to certain predictable limitations, particularly involving small sample size and heterogeneity. Recruiting patients with a rare disease is challenging. However, the approach chosen, including the use of an online questionnaire, will extend the study's reach to patients from in- and outpatient clinics and patient organizations. The three studies' sample sizes are based on similar studies in rare diseases and qualitative research.[78] Nevertheless, the results' country-wide generalizability will be limited, as they will be drawn only from German and French speaking Swiss SSc patients.

3.6 Conclusions

MANOSS is the first study assessing chronic illness management and technology readiness in a rare rheumatic disease such as SSc from the perspectives of patients, families and HPs. It will use multiple methods and stakeholder engagement to identify gaps and unmet needs affecting chronic illness management in patients living with SSc in Switzerland. The findings will serve as a roadmap informing and guiding future interventions in rare disease populations.

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Chapter 4 A rare disease patient-reported outcome measure: revision and validation of the German version of the Systemic Sclerosis Quality of Life Questionnaire (SScQoL) using the Rasch model

Agnes Kocher [1,2]; Mwidimi Ndosi [3]; Kris Denhaerynck [1]; Michael Simon [1,4]; Andrew A. Dwyer [5]; Oliver Distler [6]; Kirsten Hoeper [7]; Patrizia Künzler-Heule [1,8]; Anthony C. Redmond [9,10]; Peter M. Villiger [2]; Ulrich A. Walker [11]; Dunja Nicca [1,12]

[1] Institute of Nursing Science (INS), Department Public Health (DPH), Faculty of Medicine, University of Basel, Switzerland

[2] Department of Rheumatology, Immunology and Allergology, Inselspital, Bern University Hospital, Switzerland

[3] School of Health and Social Wellbeing, University of the West of England, Bristol, United Kingdom

[4] Nursing Research Unit, Inselspital, Bern University Hospital, University of Bern, Switzerland

[5] Boston College, Connell School of Nursing, Chestnut Hill, Massachusetts, U.S.

[6] Department of Rheumatology, University Hospital Zurich, Zurich, University of Zurich, Switzerland

[7] Hannover Medical School, Department, Rheumatology and Immunology, Hannover, Germany

[8] Department of Gastroenterology/Hepatology and Department of Nursing, Cantonal Hospital St. Gallen, Switzerland

[9] Leeds Institute of Rheumatic and Musculoskeletal Medicine, University of Leeds, Leeds, United Kingdom

[10] NIHR Leeds Biomedical Research Centre, Leeds, United Kingdom

[11] Department of Rheumatology, University Hospital Basel, Basel, Switzerland

[12] Department of Global and Public Health, Institute for Epidemiology, Biostatistics and Prevention, University of Zurich, Switzerland

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4.1 Abstract

Background

Rare disease patient-reported outcome measures (PROMs) require linguistic adaptation to overcome the challenge of geographically dispersed patient populations. Importantly, PROMs such as health-related quality of life (HRQoL) should accurately capture responses to patient-identified concerns. The Systemic Sclerosis Quality of Life Questionnaire (SScQoL) is a 29-item tool validated in six languages. Previous evaluation of the German version revealed problems with dichotomous responses. This study aimed to revise the German SScQoL, extend the response structure, and evaluate content and construct validity, reliability and unidimensionality.

Methods

The instrument validation study involved revising the German SScQoL response structure, cognitive debriefing with patients and validation using Rasch analysis. The revised SScQoL was completed by Swiss-German-speaking patients with SSc within the Swiss *MANagement Of Systemic Sclerosis (MANOSS)* study. Rasch analysis was employed to test the validity, reliability and unidimensionality of the revised instrument.

Results

Based on cognitive debriefing with patients (n=6) dichotomous items were extended to a polytomous 4-point response structure. A total of 78 patients completed the revised SScQoL. Initial analysis of the 29 items suggested the scale lacked fit to the model (χ^2=51.224, df=29, p=0.007). Grouping items into five domains resulted in an adequate fit to the Rasch model (χ^2=5.343, df=5, p=0.376) and unidimensionality (proportion of significant independent t-tests: 0.045, 95%CI: 0.016 to 0.114). Overall, the scale was well targeted, had high internal consistency (Person Separation Index, PSI=0.931) and worked consistently in patients with different demographic and clinical characteristics.

Conclusions

The revised German SScQoL has a 4-point response structure and is a valid, reliable measure. Rasch analysis is useful for validating continuous response structure of quality of life measures. Further evaluation of measurement equivalence with other German-speaking cultures is required for multinational comparisons and data pooling.

KEYWORDS

Health-related quality of life, Item response theory, Methodology, Patient-centered care, Patient reported outcome measures, Rare diseases, Rasch analysis, Rheumatology, Scleroderma, Systemic sclerosis, Validation study

4.2 Background

For many rare diseases, the natural history of the condition is poorly understood especially as it relates to the impact on health-related quality of life (HRQoL). Importantly, patients affected by rare diseases are geographically dispersed. Therefore, validated patient-reported outcome measures (PROMs) including HRQoL are needed in multiple languages. Systemic sclerosis (SSc) is a rare multisystemic, connective tissue disease associated with significant morbidity, physical and psychosocial impact.[1] Pathogenesis is dominated by vascular problems such as vasospasm of digital arteries (Raynaud's phenomenon); inflammation and activation of (auto)immune response; and fibrosis of the skin and visceral organs causing irreversible scarring and organ failure. The disease is heterogeneous in clinical manifestations (e.g. autoantibody profile, disease progression, skin involvement) and patients are typically grouped into two disease subsets: limited cutaneous systemic sclerosis (lcSSc) and diffuse cutaneous systemic sclerosis (dcSSc).

Importantly, SSc is a long-term condition and both disease subsets exhibit multiple symptoms including fatigue, hand stiffness, digital ulcers, shortness of breath, pain, and mouth-, dental- and gastrointestinal-problems.[2, 3] Psychosocial problems such as work disability, depression, fear of disease progression, and body image dissatisfaction are often evident.[4, 5] Accordingly, patients' quality of life is often severely

affected.[6, 7] Notably, the diffuse form (dcSSc) is associated with greater negative impact on quality of life compared to limited SSc (lcSSc) without organ damage.[6]

To systematically address the range of SSc effects, it is important to assess disease-specific aspects of HRQoL using an outcome measure with demonstrated reliability and validity for some specific languages. HRQoL measures are fundamental in developing PROMs for chronic conditions to evaluate targeted interventions, increase well-being (e.g., detect need for supportive care), and reduce costs (e.g., earlier detection of relapses).[8-10] Indeed, to achieve adequate sample sizes, rare disease research relies on registries (e.g. EUSTAR) and demands international/multicenter collaboration given the limited number of affected individuals.[11]

While the Health Assessment Questionnaire (HAQ) is a valid measure of physical disability, and commonly used for evaluating patients, it does not adequately take into account the psychosocial aspects or other disease-specific impact in people with SSc.[12] The Systemic Sclerosis Quality of Life Questionnaire (SScQoL) is the first PROM assessing disease-specific HRQoL in people with SSc.[13, 14] Reay et al. (2008) developed the instrument through a multi-phased process comprising qualitative interviews (one-to-one interview and focus groups) with people with SSc; development of the descriptive framework of SSc QoL; development of draft items derived from patients statements (90 items); Rasch analysis and item reduction (researchers with patient input - 29 items); test-retest with hypothesis testing and structural equation modelling.[14] The developed SScQoL has 29 items with dichotomous (true/not true) responses, scored as 'True'=1 or 'Not true'=0, total score ranges between 0-29 with higher scores indicating a greater impact of the disease and consequently, decreased HRQoL.[13, 14] The items have been grouped into five domains which map onto the International Classification of Functioning, Disability and Health (ICF) framework[13], with scores for each domain ranging as follows: function: 0-6; emotional: 0-13; sleep: 0-2; social: 0-6; and pain: 0-2.

The SScQoL underwent a cross-cultural adaptation according to a five-step procedure described by Beaton et al. (2000) and validation in six European countries.[13, 15] As part of the cross-cultural adaptation the translated versions of the SScQoL were first completed by a group of 30 patients in each of the six countries (Germany, France, Italy, Poland, Spain, Sweden, and UK) who commented on the translated version before different versions were sent for psychometric testing using Rasch analysis.[13] Findings of the adaptation suggested a seamless adaptation across all countries but Germany where patients documented problems with 10 items.[13] Specifically, problems were identified in relation to the dichotomous 'true/not true' response structure in those items. German patients indicated a desire for a broader response structure to more accurately capture the full range of responses. In the subsequent psychometric testing phase, those items in the German SScQoL revealed significant deviations from the Rasch model, confirming the problems highlighted by patients. This suggested the need for revision of the German SScQoL.[13] The need for revision was in the item wording/presentation, response structure and further psychometric testing of the German SScQoL. The aim of this present study was to review the German SScQoL, expand the response structure, and examine content validity, construct validity, unidimensionality, and reliability of the scale.

4.3 Methods

4.3.1 Design

This study consisted of two phases involving cognitive interviews for clarifying the cultural adaptation and a validation study to establish measurement validity of the adapted tool. In Phase 1, the SScQoL was refined in accordance with the International Society for Pharmacoeconomics and Outcomes Research (ISPOR) guideline.[16, 17] Phase 2, drew on data from the Swiss *MANagement Of Systemic Sclerosis (MANOSS)* cross-sectional study carried out in Switzerland.[18, 19] The *MANOSS* project aims to fill existing gaps in SSc care by developing an eHealth-enhanced rare disease chronic care model for SSc patients in Switzerland. Part of the *MANOSS* project involves conducting baseline data of SSc patients before implementing a new model of care (i.e., HRQoL). The *MANOSS* study was reviewed and approved by the responsible Swiss ethics committee in September 2018 (EKNZ 2018-01206).

4.3.2 Measures

In phase 1, the original English SScQoL and German translation were compared independently by two researchers from Germany (KH) and Switzerland (AK) respectively. The revised translations of both researchers were discussed until consensus was achieved. Subsequently, an expert committee (MN, DN, KH, AK) expanded the response structure for items 1, 3-5, 7-14, 16-17, 19-22, and 25-29 from dichotomous (true/not true) into polytomous ('always', 'usually', 'sometimes', 'never') responses. The final version was back-translated into English language by a professional translator. In cognitive interviews, a convenience sample of patients with SSc completed the new version while 'thinking aloud' and commented on relevance of the items and the response structure. Briefly, participants were encouraged to read all SScQoL items while verbalizing their thoughts concurrently. Additionally, cognitive interviews were used for cognitive debriefing to identify problems interpreting items and response options in the intended way.[20, 21] This approach has shown to be appropriate for quality of life items and for detecting unanticipated problems in participant response behaviour with minimal interviewer-imposed bias.[20, 22]

In phase 2, the validation study, German-speaking SSc patients of the *MANOSS* cross-sectional survey (March – August 2019) completed the revised (polytomous) SScQoL.[18] Participants completed either a paper format version and returned it by mail or completed the revised SScQoL in a web-based format. Participants provided sociodemographic data (sex, age, education, employment status), self-reported disease information (subset: lSSc, dSSc, Overlap syndrome[1] or unknown), and disease duration.

4.3.3 Participants

For phase 1, a convenience sample of six SSc patients spanning a range of SSc disease severity/experiences and with varied educational levels was recruited from a Swiss University hospital (Inselspital, Bern, Switzerland), a German University hospital (Medizinische Hochschule Hannover, Germany) and a German outpatient rheumatology clinic (rheumapraxis an der hase, Osnabrück, Germany). They were included if they (1) had an SSc diagnosis assured by a physician, were (2) adult (> 18 years), and (3) understood the German language. They were asked to assess the face validity of the revised SScQoL. For phase 2, patients were recruited according to the *MANOSS* protocol.[18] Patients were recruited from four Swiss University hospitals, one regional (cantonal) hospital, rheumatology outpatient clinics, and the Swiss SSc patient association. Participants were included if they were (1) adult (> 18 years), (2) received care in the Swiss healthcare system, and (3) understood the German language.

4.3.4 Data analysis

Cognitive interview data were analysed by an expert committee (AK, MN, KH, AR, DN) who made final decisions on the revised German SScQoL. For phase 2, the Swiss sample is described using descriptive statistics including frequencies, percentages, median, interquartile range (IQR), mean and standard deviation (SD). To assess whether the German SScQoL had retained its validity and reliability following the revision process, we used Rasch analysis – a psychometric testing technique that compares collected data with the Rasch model.[19, 23] Originally used in education, Rasch analysis has gained wide acceptance in the health sciences.[19] Fit to the Rasch model implies construct validity, reliability and statistical sufficiency of the item scores.[23] Rasch analysis was performed using RUMM2030 software (Perth, WA: RUMM Laboratory Pty Ltd) with the Master's Partial Credit Model (PCM), a polytomous generalization of the Rasch model, which does not impose a common threshold structure across all items.[19]

First, each of the 29 SScQoL items was assessed for 'fit' to the Rasch model to examine how the 29-item tool works as a scale. Second, items were grouped into the 5-domains established in the previous cross-cultural validation study[13] and tested as a 5-subscale measure of quality of life in SSc. Detailed descriptions of the Rasch model requirements are published elsewhere.[19] Briefly, model fit was tested by Chi-square-based fit statistics comparing differences between observed values and those expected by the model, i.e., (i) item-person interaction statistics, expressed as a Z score are expected to have a mean of zero (range − 2.5 to 2.5) and standard deviation (SD) of one and (ii) a non-significant Chi-square probability. In addition to fit statistics, internal consistency (inter-relatedness of items) demonstrating scale reliability was assessed using Person Separation Index (PSI) which functions in the same way as Cronbach's alpha but is expressed in a logit scale. A minimal PSI value of 0.7 is accepted for assessment at a group level and 0.85 for individual level.[19] Another type of reliability, the invariance of the tool (also known as differential item functioning - DIF) was established by testing if there was a response bias by different subgroups of patients based on personal and clinical characteristics (sex, age, educational background and type of SSc). DIF is tested by assessing item-trait Chi-square interaction statistic and a non-significant Bonferroni-adjusted probability to determine if the tool performs consistently across different subgroups of patients. Principal component analysis and t test-based method was used to assess (strict) unidimensionality of the scale as previously described.[24] This test compares two sets of items hypothesized to represent low levels and high levels of the construct (quality of life), selected based on the correlation between items and the first residual factor. The difference in estimates for each person are compared using an independent t-test. Unidimensionality is confirmed if ≤ 5% of t tests are significant or if the lower bound of a binomial 95% CI of the observed proportion overlap 5%.[24] A p value of <0.05 was considered significant - except when a Bonferroni adjustment was applied to account for multiple testing (i.e. 0.05/number of tests). IBM® SPSS® Version 26. Armonk, NY: IBM Corp. and RUMM2030 software, Perth, WA: RUMM Laboratory Pty Ltd were used for all quantitative analyses.

4.4 Results

4.4.1 Cognitive Interviews

A convenience sample of German-speaking patients with SSc from Germany (n=4) and Switzerland (n=2) completed the new SScQoL version using "thinking aloud" techniques for cognitive interviews (**Additional file 1**). Patients identified some problems with item wording and the remaining dichotomous (true/not true) responses. Specifically, participants desired greater differentiation beyond

a binary choice (i.e. addition of 'sometimes'). Based on patient feedback, the expert committee (AK, MN, KH, AR, DN) decided to expand the 4-point response structure to all items. A summary of issues raised for each item during back-translation and cognitive interviews is presented in **Additional file 1**.

4.4.2 Cross-sectional validation study

Patient characteristics

The validation study sample comprised 78 Swiss-German patients with SSc. They had a median self-reported disease duration (i.e. date of diagnosis) of 8 years (IQR: 4 to 13 years) and the majority, 58/78 (74.7%) were women. Participants' sociodemographic data are summarized in **Table 1**. The descriptive results including frequency and distribution of all items are shown in **Additional file 2**.

Table 1 Validation study: Participant characteristics (n=78)

Characteristic	n (%)
Instrument format	
Online survey	25 (32.1%)
Paper survey	53 (67.9%)
Sex	
Female	59 (75.6%)
Male	17 (21.8%)
Not reported	2 (2.6%)
Age [years, median (IQR)]	61 (49–71)
Disease duration, self-reported [years, median (IQR)]	8 (4–13)
Not reported	5
Disease subset, self-reported	
Limited cutaneous systemic sclerosis (lSSc)	28 (35.9%)
Diffuse cutaneous systemic sclerosis (dSSc)	22 (28.2%)
Overlap syndrome[1]	3 (3.9%)
Don't' know	20 (25.6%)
Not reported	5 (6.4%)
Comorbidities, self-reported	
Gastrointestinal problems	46 (58.2%)
Osteoarthritis	32 (40.5%)
Backpain	31 (39.2%)
Lung problems	28 (35.4%)
High blood pressure	24 (30.4%)
Heart problems	22 (27.8%)
Depression	12 (15.2%)
Anemia or other blood problems	10 (12.7%)
Liver problems	9 (11.4%)
Diabetes	5 (6.3%)
Kidney problems	3 (3.8%)
Marital status	

Single	11 (14.1%)
Married/cohabiting	52 (66.7%)
Divorced, separated, or widowed	13 (16.7%)
Not reported	2 (2.5%)
Education	
Tertiary level (e.g. university of applied science)	32 (41.1%)
Upper secondary (e.g. Baccalaureate schools)	34 (43.5%)
Compulsory (e.g. high school)	10 (12.8%)
No completed school education or vocational training	1 (1.3%)
Not reported	1 (1.3%)
Employment[2]	
Employed	38 (48.7%)
Working full time (80-100% employed)	17/38 (21.8%)
Working part time (less than 80% employed)	21/38 (26.9%)
Looking for work	4 (5.1%)
In training (student, vocational education)	7 (9.0%)
Retired	19 (24.4%)
On disability or sick leave	10 (12.8%)
Not reported	1 (1.3%)

[1]*Overlap syndrome:* Condition in which patients have concurrent clinical manifestations of multiple distinct immune diseases (e.g. overlap between systemic sclerosis and rheumatoid arthritis) [2]*Multiple answers were allowed*

Response scale structure

After expanding the response structure, item characteristic curves (ICC) revealed that 22/29 displayed ordered thresholds suggesting that the response categories represented by the thresholds were ordered from low to high (quality of life) as expected (**Additional file 3**). Collapsing some categories and rescoring items with disordered thresholds improved the individual item fit but not the overall scale.

Fit to the model

Item fit statistics for individual items are shown in **Table 2a**. Most individual items, appeared to adequately fit the model limits (residuals within the -2.5 to 2.5 range) with non-significant Chi-Square Bonferroni-adjusted probability (p=0.0017). The sole exception was item 29 with a fit residual of -2.573. This may have impacted on the overall validity of the scale (summary statistics indicating deviation from the model) as shown in **Table 3** (Chi-Square = 52.198, DF= 29, p=0.005). When the items were grouped in their respective domains and analysed (**Table 2b**), each domain was found to adequately fit the model. Summary statics indicate the 5-domain structure has adequate fit to the model (Chi-Square = 5.269, df = 5, p=0.384) (**Table 3**). The reliability of the scale was high (PSI = 0.915). The proportion of significant t-tests was <5% (i.e. 0.0649, 95% CI: 0.016 to 0.114) supporting the unidimensionality of the scale.

Table 2 Fit statistics for individual items and subscales

Table 2a: Individual item fit statistic

Item	Location	SE	Fit Residual	DF	Chi-Square	DF	*p*-value*
Item 1	-0.0690	0.1980	0.7720	71.30	0.7350	1	0.3913
Item 2	0.8040	0.2000	-0.1080	71.30	0.0950	1	0.7575
Item 3	-0.5990	0.2040	0.7390	69.45	0.4630	1	0.4961
Item 4	-0.5850	0.2080	1.4080	70.37	1.7500	1	0.1859
Item 5	0.5520	0.1870	2.0380	71.30	6.9000	1	0.0086
Item 6	-0.7860	0.2240	0.4820	69.45	0.0430	1	0.8361
Item 7	0.5300	0.1650	-0.0030	70.37	0.0590	1	0.8088
Item 8	0.3000	0.1700	-1.5930	70.37	0.7270	1	0.3940
Item 9	0.1440	0.1760	1.4490	70.37	0.5550	1	0.4562
Item 10	0.1980	0.1720	-1.0090	70.37	0.8430	1	0.3586
Item 11	-0.0240	0.1880	-0.0300	71.30	1.1780	1	0.2777
Item 12	1.9560	0.1660	2.0370	71.30	1.6340	1	0.2011
Item 13	0.0080	0.1910	-1.3440	69.45	1.2680	1	0.2602
Item 14	1.3880	0.1640	-0.1000	70.37	0.0840	1	0.7720
Item 15	0.5680	0.1770	-0.5930	69.45	1.2140	1	0.2705
Item 16	-0.1550	0.1860	-0.1190	68.52	0.0040	1	0.9525
Item 17	-0.1520	0.1970	-0.1290	69.45	0.5860	1	0.4438
Item 18	1.2400	0.1670	0.5370	70.37	0.0130	1	0.9100
Item 19	-1.6870	0.2340	-1.2330	70.37	4.8620	1	0.0274
Item 20	-0.0900	0.1790	0.6500	70.37	1.6790	1	0.1950
Item 21	-2.0530	0.2340	-1.4820	69.45	7.6950	1	0.0055
Item 22	0.8940	0.1670	-0.1830	70.37	0.0140	1	0.9060
Item 23	1.0750	0.1620	1.6730	70.37	5.2190	1	0.0223
Item 24	-1.8890	0.2630	-0.2340	69.45	0.0220	1	0.8822
Item 25	-0.6260	0.1870	0.4180	70.37	0.2140	1	0.6437
Item 26	0.3040	0.1910	-1.2790	70.37	2.9170	1	0.0876
Item 27	-0.6810	0.2030	-1.3730	71.30	4.9500	1	0.0261
Item 28	-0.5330	0.2000	-1.2820	70.37	1.2640	1	0.2609
Item 29	-0.0350	0.1690	**-2.5730**	71.30	4.2360	1	0.0396

Table 2b: Fit statistics for each domain (subscale)

Domain	Location	SE	Fit Residual	DF	Chi-Square	DF	*p*-value*
Function	0.618	0.129	0.215	51.65	1.339	1	0.2473
Emotional	-0.075	0.079	-1.05	49.4	0.202	1	0.6528
Sleep	-0.294	0.172	0.236	53.15	0.038	1	0.8445
Social	-0.16	0.109	-0.22	50.15	1.933	1	0.1644
Pain	-0.089	0.19	-0.13	51.65	1.757	1	0.1850

DF, degree of freedom; SE, standard error; p-value*, Bonferroni adjusted p-value = 0.05/number of tests (items), Numbers in bold suggest deviation from the model

Table 3 Summary fit statistics

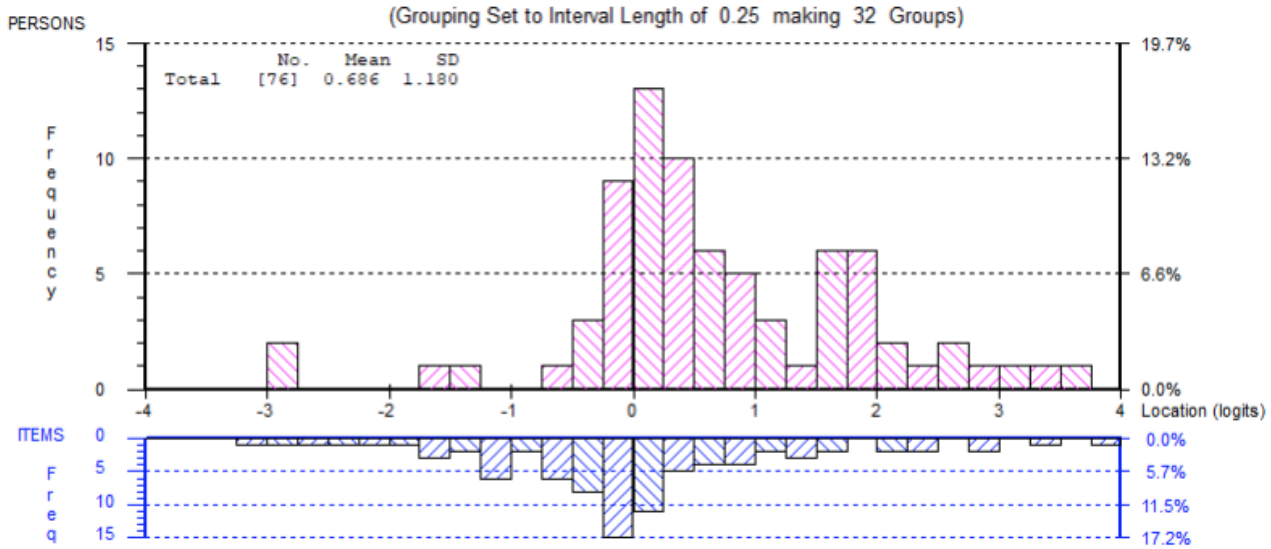
Analysis	Item Fit Residual Mean	Item Fit Residual SD	Person Fit Residual Mean	Person Fit Residual SD	Chi Square Interaction Value (df)	*p*	PSI	N	Unidimensionality Independent t-tests (95%CI)
Individual items	-0.0849	1.1739	-0.19	1.313	51.2238	0.0066	0.990	77	0.256 (0.208 to 0.305)
Five domains	0.1019	0.9283	-0.25	0.917	5.3426	**0.3755**	0.915	77	0.0649 (**0.016** to 0.114)
Model fit	*0*	*1*	*0*	*1*		***>0.05***	*>0.7*		*Lower bound 95%CI <0.05)*

SD, Standard deviation; df, degrees of freedom; PSI, Person separation index

Targeting of persons and items

The revised 29-item German SScQoL version integrating a 4-point response option for all items was shown to cover the full range of participants' quality of life. The person–item threshold distribution (**Figure 1**) depicts that the items are well mapped against all persons.

Figure 1. Person-item distribution for all 29 items of the German Systemic Sclerosis Quality of Life Questionnaire (SScQoL)



The graph displays the distribution of items: the x-axis is the logit score and represents the interval scaling of the items according to the Rasch model, with − 4 being good quality of life and 4 being poor quality of life. The lower part of each histogram is where individual items are located along the scale; the top part of histogram represents the number of people and their total SScQoL logit score. The graph shows the targeting of items to persons.

Invariance of the SScQoL

The test of invariance found that there were no significant DIF by any personal characteristics (age, sex, education level) or disease subcategory and disease duration. The results of DIF analysis are presented in **Additional file 4 and 5**.

Testing the fit of the dichotomized scale

As the response structure of the scale has been expanded to 4 responses, comparison of measures with other countries would require a cross-cultural measurement equivalence which may first require dichotomizing responses of the revised scale. For all items, collapsing categories 1, 2 and 3 vs category 4 provided the best model fit in individual items (domains) and the summary statistics (**Additional file 6**).

4.5 Discussion

In the present study, we revised the German SScQoL with the aim to linguistically review the German SScQoL, expand the response structure, and used Rasch analysis to examine construct validity, unidimensionality, and reliability. Overall, the scale was well targeted, had high internal consistency, and worked consistently across patients with varied demographic and clinical characteristics. The present data suggest the revised German SScQoL can now be used with confidence in German-speaking countries.

Cognitive interviews included patients from Germany and Switzerland to gain an understanding of how well patients comprehend the concepts intended by the items and how the new response structure worked for them. Cognitive interviews and subsequent expert discussions revealed translation and language issues that are essential for using the SScQoL in all four German-speaking countries (Austria, Germany, Liechtenstein, Switzerland). We made minor linguistic changes enabling use across German-speaking countries. The initial validation study[13] identified ten items that patients found too restrictive and also lacked fit to the Rasch model. In the present study, cognitive interviews informed modification of the response structure thereby facilitating more accurate responses. Polytomous responses ('always', 'usually', 'sometimes', 'never') were applied to all items - although linguistically, this may not always make sense (e.g. for item Q23: *'I have had to stop some of my hobbies'*). Importantly, there is no definitive consensus on the most appropriate translation or questionnaire response format for measuring HRQoL.[15] In the present study, expanding all items to a uniform, 4-point response structure improved the validity and reliability of the German SScQoL. Although there is not necessarily semantic or linguistic equivalence with the English SScQoL, expert meetings and cognitive interviews support conceptual equivalence between the English and German versions.

Rasch analysis confirmed that measurement properties (construct validity, reliability, and unidimensionality) of the SScQoL were retained following its revision in German. Similar to the prior multinational cross-cultural validation using Rasch analysis[13], the SScQoL demonstrated adequate fit when the items were grouped into the five domains. Validity, reliability and unidimensionality of the German SScQoL was demonstrated. Additionally, the tool had good targeting for patients with different levels of HRQoL and was shown to be free of response bias for age, sex, education level, disease subcategory, and disease duration (DIF analysis shown in **Additional file 4** and 5). Overall, fit to the Rasch model confirmed that the measurement properties of the revised German SScQoL version integrating a 4-point response option were retained.

Having a 4-point response structure means that the total score will range from 0 to 87 (i.e. scoring always = 3, usually = 2, sometimes = 1, never = 0) which differs from the original SScQoL (score range: 0-29). For interoperability in research settings, the polytomous scale could be re-scored dichotomously (i.e. 'always', 'usually' or 'sometimes' = 'true'/1, 'never' = 'not true'/0). We tested this scoring approach and it showed adequate fit to the model (**Additional file 6**). Instructions for scoring are included in **Additional file 7**.

The study has several limitations. First, the validation was only planned when the *MANOSS* project was already established and did not allow for confirmation of the self-reported diagnosis, multiple measurement points and multinational validation.[18] For the cognitive interviews, only six Swiss and German patients were included. Including more patients (i.e. from Austria and Liechtenstein) would have been ideal, although this was not possible. Field testing with more patients from all German-speaking countries could further improve the linguistic presentation of the SScQoL, although we believe conceptual equivalence is more important.[15] Our validation sample only included Swiss German-speaking patients. Thus, caution is warranted when attempting to extend findings to other German-speaking populations. Further studies should include patients from Austria, Germany and Liechtenstein to confirm the robustness of the German SScQoL and ensure transferability. Last, while the instrument is well targeted and the sample size adequate for its validation[25], calibration of the scale into interval-level (transformed) scores was beyond the scope of this study. Future work should include establishing responsiveness of the SScQoL and calibration or cross-cultural comparability studies using data from other European countries.

4.6 Conclusions

The data presented herein contributes to the existing literature through the successful revision and validation of the SScQoL, with a new 4-point response structure for the German speaking context. These data are relevant to the broader rare disease research community as they demonstrate that cognitive interviews and Rasch analysis can improve the psychometric properties of PROMs while enabling interoperability of findings. Further cross-cultural validity tests are required to fully demonstrate measurement equivalence with other SScQoL versions, thereby enabling broad, multilinguistic comparison and data pooling. Beyond research, the new German SScQoL is valid measure that can be used with confidence in clinical practice. The new version of the SScQoL can be obtained at https://doi.org/10.5518/325.

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4.8 Supplementary information

Additional file 1

Back-translation, issues and agreements for each item of the German Systemic Sclerosis Quality of Life Questionnaire (SScQoL)

Item	English Original	German Original	Back-translation 1 (BT1)	German revised	Answer options	Back-translation 2 (BT2)	Issues raised in cognitive interviews	Agreement
+1	I can't do anything without really thinking it through	Ich kann nichts tun, ohne vorher gründlich drüber nachzudenken	I can't do anything without thinking about it first	No changes	Immer, meistens, manchmal, nie	I can't do anything without thinking it through in advance		
2	It's always on my mind	Die Erkrankung ist ständig in meinen Gedanken	The disease is constantly in my mind	No changes	No changes	My illness is always on my mind	More response options are requested.	Add response options
°+3	I worry that I let people down	Ich befürchte/ sorge mich, dass ich andere Menschen enttäusche	I fear/ worry that I will disappoint other people	Ich mache mir Sorgen, dass ich andere Menschen im Stich lasse	Immer, meistens, manchmal, nie	I worry about letting other people down		
*+4	My condition makes me angry	Mein derzeitiger Gesundheitszustand macht mich wütend	My current state of health makes me angry	No changes	Immer, meistens, manchmal, nie	My current state of health makes me very angry	Questions 4 and 5 are very similar.	No changes
°+5	I get upset when I can't do things	Ich rege mich auf, wenn ich etwas nicht mehr selbst tun/ erledigen kann	I get upset when I can't do something by myself anymore	Ich rege mich auf, wenn ich etwas nicht mehr tun kann	Immer, meistens, manchmal, nie	I get upset when there is something I can't do anymore	Questions 4 and 5 are very similar.	Grammatical changes
6	I often get frustrated	Ich bin oft frustriert	I am often frustrated	No changes	No changes	I often get frustrated	More response options are requested.	Add response options

+7	I cannot rely on how I will be tomorrow	Ich kann mich nicht darauf verlassen, wie es mir am nächsten Tag gehen wird	I can't count on how I'm gonna feel the next day	No changes	Immer, meistens, manchmal, nie	I can't tell how I'll be feeling tomorrow		
°+8	I feel like I'm fighting all the time	Ich fühle mich wie in einem ständigen Kampf	I feel like I'm in a constant battle	Ich fühle mich, als ob ich ständig kämpfen würde	Immer, meistens, manchmal, nie	I feel like I'm fighting a constant battle	The question is too theatrical and hard to answer.	No changes possible
*+9	My condition means I have disturbed sleep	Durch meine Erkrankung habe ich Schlafstörungen	My illness has caused me to have trouble sleeping	No changes	Immer, meistens, manchmal, nie	Because of my illness I have trouble sleeping	Question 9 and 20 are similar.	No changes possible
°+10	It has affected me a lot socially	Die Krankheit beeinträchtigt mein Sozialleben sehr	The disease severely restricts my social life	Die Erkrankung beeinträchtigt mein Sozialleben sehr	Immer, meistens, manchmal, nie	My illness severely restricts my social life		"It" is always changed into „Erkrankung"
°*+11	It has affected the health of people around me	Sie hat Einfluss auf das Befinden der Menschen in meinem Umfeld	It has an influence on the well-being of the people around me	Die Erkrankung hat Einfluss auf das Befinden der Menschen in meinem Umfeld	Immer, meistens, manchmal, nie	My illness influences the sense of well-being of the people around me	What does "It" mean? Question 11 and 13 are very similar. Hard to answer.	"It" is always changed into „Erkrankung"
*+12	My hands don't work as well as they did	Meine Hände funktionieren nicht mehr so gut wie früher	My hands don't work as well as they used to	No changes	Immer, meistens, manchmal, nie	I can't use my hands as well as I used to	Hard to answer.	No changes possible

*+13	It puts a strain on my personal relationships	Die Erkrankung belastet meine persönlichen Beziehungen	The disease strains my personal relationships	No changes	Immer, meistens, manchmal, nie	My illness puts a strain on my personal relationships		
°+14	I need to rest more often	Ich muss mich häufiger ausruhen/ öfter Pausen einlegen	I need to rest more often/ take breaks more often	Ich muss mich häufiger ausruhen	Immer, meistens, manchmal, nie	I have to take more frequent breaks		
*15	Any sort of activity is difficult	Jede Art von Tätigkeit ist mit Schwierigkeiten verbunden	Every type of activity is associated with difficulties	No changes	No changes	Every activity involves some kind of difficulty	It feels wrong to answer with correct or wrong. The question is unclear.	No changes possible Add response options
°+16	I avoid certain social situations because I am embarrassed	Ich vermeide manchmal gesellschaftliche Situationen, um mich nicht in Verlegenheit zu bringen	I sometimes avoid social situations so as not to embarrass myself	Ich vermeide gewisse gesellschaftliche Situationen, um mich nicht in Verlegenheit zu bringen	Immer, meistens, manchmal, nie	I avoid getting into certain situations with others to prevent embarrassment		
+17	I take to heart things which wouldn't have worried me before	Ich nehme mir Dinge zu Herzen, die mich früher nicht bedrückt hätten	I take things to heart that wouldn't have bothered me before	No changes	Immer, meistens, manchmal, nie	There are things that didn't used to bother me but now really get me down		
18	Life is just not what it was	Das Leben ist einfach nicht mehr wie früher	Life just isn't the same anymore	No changes	No changes	Life just isn't like it used to be	One patient is annoyed by the many similar questions.	No changes possible Add response options

°*+19	I can’t cope at all	Ich komme mit der Erkrankung irgendwie nicht zurecht	I don't know how I'm coping with the disease	Ich komme überhaupt nicht zurecht	Immer, meistens, manchmal, nie	I’m simply not able to cope	The question is "dumbly asked", what does this refer to? What can you not cope with?	No changes possible
*+20	Sleeping badly has affected me a lot	Schlecht zu schlafen beeinträchtigt mich sehr	Sleeping badly affects me very much	No changes	Immer, meistens, manchmal, nie	Not sleeping well is a major problem for me	Question 9 and 20 are similar.	No changes possible
+21	I feel very isolated	Ich fühle mich sehr isoliert	I feel very isolated	No changes	Immer, meistens, manchmal, nie	I feel very isolated		
°+22	Household tasks can be a problem	Hausarbeiten können ein Problem darstellen	Housework can be a problem	Hausarbeiten können ein Problem sein	Immer, meistens, manchmal, nie	Household tasks can pose problems		
23	I have had to stop some of my hobbies	Ich musste einige meiner Hobbies aufgeben	I had to give up some of my hobbies	No changes	No changes	I have had to give up some of my hobbies		Add response options
°24	I feel guilty at being ill	Ich habe Schuldgefühle wegen der Krankheit	I feel guilty about the illness	Ich fühle mich schuldig, krank zu sein	No changes	I feel guilty for being ill	Question is stupid and needless. More response options are requested.	No changes possible Add response options

°*+25	I struggle to wash myself as I would like	Ich habe Schwierigkeiten mich selbst so zu waschen, wie ich gerne würde	I have trouble washing myself the way I'd like	Ich habe Schwierigkeiten mich selbst so zu waschen, wie ich gerne möchte	Immer, meistens, manchmal, nie	I try to wash myself as I was used to doing before	Question is difficult to understand.	No changes possible
+26	Pain limits what I can do	Schmerzen schränken mich in meinem Handeln ein	Pain restricts me in my actions	Die Schmerzen schränken mich in meinem Handeln ein	Immer, meistens, manchmal, nie	Pain restricts my activities		
*+27	I feel helpless	Ich fühle mich hilflos	I feel helpless	No changes	Immer, meistens, manchmal, nie	I feel helpless		
+28	Pain tires me out	Schmerzen erschöpfen/ ermüden mich	Pain exhausts/ tires me out	Die Schmerzen laugen mich aus	Immer, meistens, manchmal, nie	The pain wears me out		
+29	I miss being able to sort things out	Ich vermisse es, meine Angelegenheiten selbst erledigen zu können	I miss being able to do my own business	No changes	Immer, meistens, manchmal, nie	I miss taking care of my own affairs		

* Problematic items detected by Ndosi et al. [11]; ° Revised wording; + Revised answer option

Additional file 2

Frequency and level of quality of life of all items of the new German Systemic Sclerosis Quality of Life Questionnaire (SScQoL) version (N=78)

	Item name German (D) & English (E)	**Proportion of answers over scale (n, %)**					**Mean (SD)**	**Median**	**P25**	**P75**	**Min**	**Max**
		1 Always	**2 Usually**	**3 Some-times**	**4 Never**	**Not reported**						
Q1	D: Ich kann nichts tun, ohne vorher gründlich darüber nachzudenken E: I can't do anything without really thinking it through	5 (6.4%)	7 (9.0%)	40 (51.3%)	26 (33.3%)	0	3.12 (0.82)	3	3	4	1	4
Q2	D: Die Erkrankung ist ständig in meinen Gedanken E: It's always on my mind	8 (10.3%)	10 (12.8%)	49 (62.8%)	11 (14.1%)	0	2.81 (0.81)	3	3	3	1	4
Q3	D: Ich mache mir Sorgen, dass ich andere Menschen im Stich lasse E: I worry that I let people down	3 (3.9%)	10 (12.8%)	32 (41.0%)	31 (39.7%)	2 (2.6%)	3.20 (0.82)	3	3	4	1	4
Q4	D: Mein derzeitiger Gesundheitszustand macht mich wütend E: My condition makes me angry	4 (5.1%)	7 (9.0%)	36 (46.1%)	30 (38.5%)	1 (1.3%)	3.19 (0.81)	3	3	4	1	4
Q5	D: Ich rege mich auf, wenn ich etwas nicht mehr tun kann E: I get upset when I can't do things	7 (9.0%)	16 (20.5%)	40 (51.3)	15 (19.2%)	0	2.81 (0.85)	3	2	3	1	4
Q6	D: Ich bin oft frustriert E: I often get frustrated	3 (3.8%)	5 (6.4%)	38 (48.7%)	30 (38.5%)	2 (2.6%)	3.25 (0.75)	3	3	4	1	4
Q7	D: Ich kann mich nicht darauf verlassen, wie es mir am nächsten Tag gehen wird E: I cannot rely on how I will be tomorrow	11 (14.1%)	15 (19.2%)	24 (30.8%)	27 (34.6%)	1 (1.3%)	2.87 (1.06)	3	2	4	1	4

	Item name German (D) & English (E)	Proportion of answers over scale (n, %)					Mean (SD)	Median	P25	P75	Min	Max
Q8	D: Ich fühle mich, als ob ich ständig kämpfen würde E: I feel like I'm fighting all the time	10 (12.8%)	11 (14.1%)	27 (34.6%)	29 (37.2%)	1 (1.3%)	2.97 (1.03)	3	2	4	1	4
Q9	D: Durch meine Erkrankung habe ich Schlafstörungen E: My condition means I have disturbed sleep	8 (10.3%)	8 (10.3%)	32 (41.0%)	29 (37.2%)	1 (1.3%)	3.06 (0.95)	3	3	4	1	4
Q10	D: Die Erkrankung beeinträchtigt mein Sozialleben sehr E: It has affected me a lot socially	9 (11.5%)	11 (14.1%)	27 (34.6%)	30 (38.5%)	1 (1.3%)	3.01 (1.01)	3	2	4	1	4
Q11	D: Die Erkrankung hat Einfluss auf das Befinden der Menschen in meinem Umfeld E: It has affected the health of people around me	6 (7.7%)	11 (14.1%)	33 (42.3%)	28 (35.9%)	0	3.06 (0.90)	3	3	4	1	4
Q12	D: Meine Hände funktionieren nicht mehr so gut wie früher E: My hands don't work as well as they did	26 (33.3%)	18 (23.1%)	27 (34.6%)	7 (9.0%)	0	2.19 (1.01)	2	1	3	1	4
Q13	D: Die Erkrankung belastet meine persönlichen Beziehungen E: It puts a strain on my personal relationships	7 (9.0%)	6 (7.7%)	35 (44.9%)	28 (35.9%)	2 (2.6%)	3.11 (0.90)	3	3	4	1	4
Q14	D: Ich muss mich häufiger ausruhen E: I need to rest more often	19 (24.4%)	19 (24.4%)	24 (30.8%)	15 (19.2%)	1 (1.3%)	2.45 (1.07)	3	2	3	1	4
Q15	D: Jede Art von Tätigkeit ist mit Schwierigkeiten verbunden E: Any sort of activity is difficult	10 (12.8%)	12 (15.4%)	33 (42.3%)	21 (26.9%)	2 (2.6%)	2.86 (0.98)	3	2	4	1	4

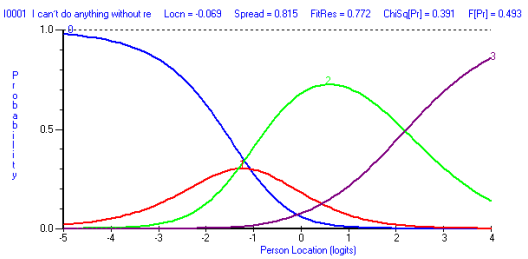
	Item name German (D) & English (E)	Proportion of answers over scale (n, %)					Mean (SD)	Median	P25	P75	Min	Max
Q16	D: Ich vermeide gewisse gesellschaftliche Situationen, um mich nicht in Verlegenheit zu bringen E: I avoid certain social situations because I am embarrassed	5 (6.4%)	10 (12.8%)	28 (35.9%)	32 (41.0%)	3 (3.8%)	3.16 (0.90)	3	3	4	1	4
Q17	D: Ich nehme mir Dinge zu Herzen, die mich früher nicht bedrückt hätten E: I take to heart things which wouldn't have worried me before	5 (6.4%)	8 (10.3%)	35 (44.9%)	28 (35.9%)	2 (2.6%)	3.13 (0.85)	3	3	4	1	4
Q18	D: Das Leben ist einfach nicht mehr wie früher E: Life is just not what it was	17 (21.8%)	16 (20.5%)	30 (38.5%)	14 (17.9%)	1 (1.3%)	2.53 (1.03)	3	2	3	1	4
Q19	D: Ich komme überhaupt nicht zurecht E: I can’t cope at all	2 (2.6%)	4 (5.1%)	21 (26.9%)	50 (64.1%)	1 (1.3%)	3.55 (0.72)	4	3	4	1	4
Q20	D: Schlecht zu schlafen beeinträchtigt mich sehr E: Sleeping badly has affected me a lot	6 (7.7%)	10 (12.8%)	29 (37.2%)	32 (41.0%)	1 (1.3%)	3.13 (0.92)	3	3	4	1	4
Q21	D: Ich fühle mich sehr isoliert E: I feel very isolated	1 (1.3%)	6 (7.7%)	21 (26.9%)	48 (61.5%)	2 (2.6%)	3.53 (0.70)	4	3	4	1	4
Q22	D: Hausarbeiten können ein Problem sein E: Household tasks can be a problem	13 (16.7%)	19 (24.4%)	26 (33.3%)	19 (24.4%)	1 (1.3%)	2.66 (1.03)	3	2	3	1	4
Q23	D: Ich musste einige meiner Hobbies aufgeben E: I have had to stop some of my hobbies	17 (21.8%)	14 (17.9%)	29 (37.2%)	17 (21.8%)	1 (1.3%)	2.60 (1.07)	3	2	3	1	4
Q24	D: Ich fühle mich schuldig, krank zu sein E: I feel guilty at being ill	2 (2.6%)	2 (2.6%)	16 (20.5%)	56 (71.8%)	2 (2.6%)	3.66 (0.66)	4.00	3.00	4.00	1.00	4.00
Q25	D: Ich habe Schwierigkeiten mich selbst so zu waschen, wie ich gerne möchte E: I struggle to wash myself as I would like	7 (9.0%)	3 (3.8%)	7 (9.0%)	60 (76.9%)	1 (1.3%)	3.56 (0.94)	4.00	4.00	4.00	1.00	4.00

	Item name German (D) & English (E)	Proportion of answers over scale (n, %)					Mean (SD)	Median	P25	P75	Min	Max
Q26	D: Die Schmerzen schränken mich in meinem Handeln ein E: Pain limits what I can do	7 (9.0%)	13 (16.7%)	37 (47.4%)	20 (25.6%)	1 (1.3%)	2.91 (0.89)	3	2	4	1	4
Q27	D: Ich fühle mich hilflos E: I feel helpless	5 (6.4%)	3 (3.8%)	24 (30.8%)	46 (59.0%)	0	3.42 (0.85)	4	3	4	1	4
Q28	D: Die Schmerzen laugen mich aus E: Pain tires me out	5 (6.4%)	6 (7.7%)	28 (35.9%)	38 (48.7%)	1 (1.3%)	3.29 (0.87)	3	3	4	1	4
Q29	D: Ich vermisse es, meine Angelegenheiten selbst erledigen zu können E: I miss being able to sort things out	9 (11.5%)	9 (11.5%)	21 (27.0%)	39 (50.0%)	0	3.15 (1.03)	3	3	4	1	4

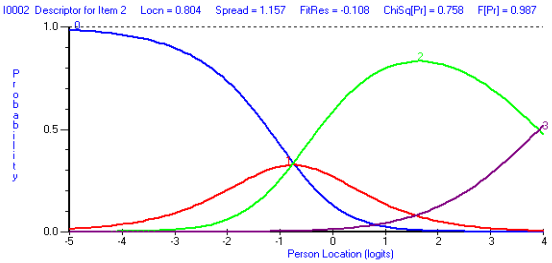
Additional file 3

Item characteristic curves (ICC) for all items

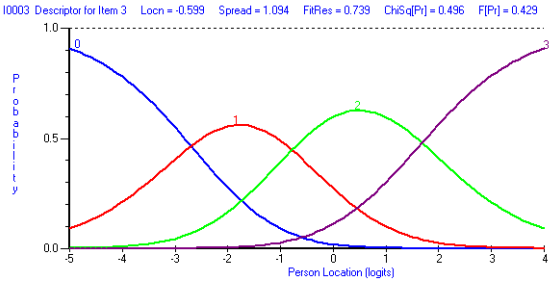
Item 1



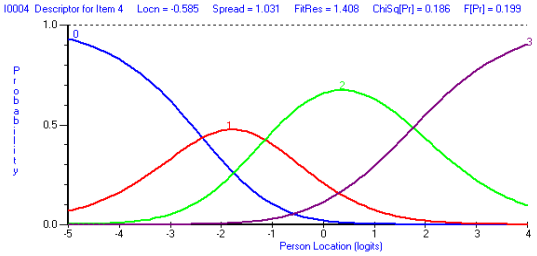
Item 2



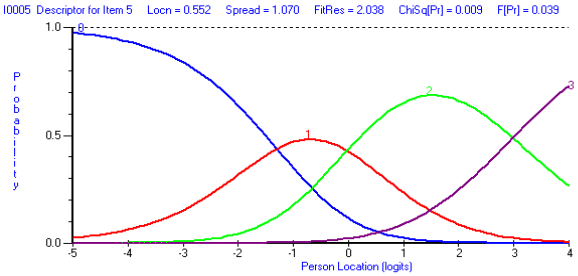
Item 3



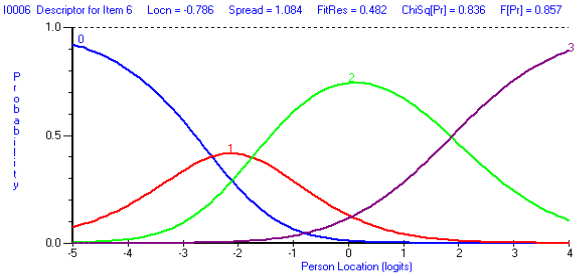
Item 4



Item 5



Item 6



Additional file 4

Differential item functioning (DIF) analysis A

	DIF by Sex (M vs F) = Not significant				DIF by Age (62 vs 63+) = Not significant				DIF by education level (7 levels) = Not significant				DIF by disease duration (9 vs 10+) = Not significant				DIF by disese subgroup (lSSc/dSSc/uSSc/Unknown) = Not significant			
Item	MS	F	DF	p-value*	MS	F	DF	p-value*	MS	F	DF	p-value*	MS	F	DF	p-value*	MS	F	DF	p-value*
Item 1	0.1109	0.1001	1	0.7526	1.9376	1.8028	1	0.1837	0.7407	0.6501	6	0.6898	0.0008	0.0006	1	0.9799	0.92143	0.8143	3	0.4907
Item 2	0.9953	1.0416	1	0.3109	2.5012	2.8352	1	0.0967	0.5090	0.4950	6	0.8097	2.8951	3.7588	1	0.0566	1.33392	1.4829	3	0.2276
Item 3	0.3045	0.3015	1	0.5847	2.0173	1.9211	1	0.1703	3.1871	3.3784	6	0.0061	0.3037	0.2742	1	0.6023	0.08655	0.0746	3	0.9734
Item 4	0.0533	0.0414	1	0.8394	5.6203	4.6388	1	0.0348	1.9128	1.6386	6	0.1516	0.5296	0.4328	1	0.5128	1.30932	1.0011	3	0.3983
Item 5	0.9894	0.7703	1	0.3831	0.1466	0.1071	1	0.7445	0.5295	0.3586	6	0.9022	0.0002	0.0002	1	0.9889	1.61076	1.4188	3	0.2454
Item 6	0.1029	0.0946	1	0.7593	2.6132	2.5456	1	0.1152	0.5440	0.4810	6	0.8200	1.0914	1.0117	1	0.3181	1.29548	1.2216	3	0.3094
Item 7	0.0218	0.0220	1	0.8825	1.0281	1.0611	1	0.3066	0.5762	0.6444	6	0.6943	1.7045	1.8459	1	0.1788	1.00481	1.1758	3	0.3261
Item 8	0.6689	1.0237	1	0.3151	4.1053	7.0444	1	0.0099	0.8800	1.3264	6	0.2590	1.5758	2.4677	1	0.1208	0.56471	1.0201	3	0.3897
Item 9	0.3950	0.3947	1	0.5319	0.7810	0.5517	1	0.4602	1.1868	1.1186	6	0.3620	0.0061	0.0044	1	0.9473	2.15465	1.6054	3	0.1968
Item 10	0.1662	0.2226	1	0.6385	0.0562	0.0747	1	0.7854	0.4779	0.5930	6	0.7347	1.7091	2.2860	1	0.1351	0.23713	0.3081	3	0.8194
Item 11	2.2102	2.7641	1	0.1008	0.7307	0.7878	1	0.3778	0.7195	0.8213	6	0.5576	0.1186	0.1313	1	0.7182	1.38813	1.4720	3	0.2305
Item 12	0.8407	0.4672	1	0.4965	4.0381	2.5680	1	0.1136	1.3813	0.7263	6	0.6300	1.3914	0.7588	1	0.3867	1.77195	0.9691	3	0.4129
Item 13	0.0022	0.0032	1	0.9548	0.4744	0.7401	1	0.3926	0.2189	0.3072	6	0.9309	0.7383	1.0964	1	0.2988	0.92594	1.3496	3	0.2664
Item 14	0.8060	0.8604	1	0.3568	1.5836	1.6795	1	0.1993	0.1553	0.1493	6	0.9885	0.0001	0.0001	1	0.9924	1.10229	1.1866	3	0.3219
Item 15	0.0011	0.0013	1	0.9718	6.5196	8.4535	1	0.0049	0.2081	0.2695	6	0.9491	0.0905	0.1147	1	0.7359	0.48261	0.5642	3	0.6406
Item 16	0.0604	0.0620	1	0.8041	0.1303	0.1407	1	0.7087	1.4919	1.7747	6	0.1197	4.1714	4.7135	1	0.0335	0.19302	0.1957	3	0.8990
Item 17	0.0113	0.0118	1	0.9137	0.4919	0.5460	1	0.4625	0.6322	0.6574	6	0.6841	0.6411	0.6938	1	0.4078	0.91825	0.9483	3	0.4228
Item 18	0.0271	0.0240	1	0.8773	2.4678	2.5611	1	0.1141	0.2772	0.2291	6	0.9657	1.9227	1.7451	1	0.1909	4.29586	4.5724	3	0.0058
Item 19	0.1320	0.2377	1	0.6274	0.6241	1.1622	1	0.2848	0.4540	0.8276	6	0.5531	0.2442	0.4230	1	0.5176	0.37255	0.6246	3	0.6017
Item 20	0.0017	0.0015	1	0.9695	0.9790	0.8594	1	0.3571	0.7515	0.6323	6	0.7038	0.2903	0.2529	1	0.6166	1.60798	1.4700	3	0.2311
Item 21	0.2982	0.7187	1	0.3995	0.5608	1.2711	1	0.2635	0.2327	0.4860	6	0.8163	0.6207	1.2547	1	0.2666	0.90736	2.0239	3	0.1196
Item 22	1.8994	2.0254	1	0.1591	8.6295	10.2874	1	0.0020	0.6926	0.6871	6	0.6607	3.2329	3.9684	1	0.0503	1.94987	2.2745	3	0.0884
Item 23	1.6949	1.2076	1	0.2755	2.5257	1.8287	1	0.1807	1.7147	1.1836	6	0.3268	1.8298	1.4407	1	0.2342	1.32007	1.0292	3	0.3858
Item 24	1.7763	2.0754	1	0.1542	0.0384	0.0452	1	0.8323	0.9067	1.0678	6	0.3917	0.0405	0.0463	1	0.8303	0.18602	0.1944	3	0.8999
Item 25	1.5640	1.1936	1	0.2783	0.1401	0.1025	1	0.7498	1.2638	0.9177	6	0.4884	0.0138	0.0098	1	0.9215	1.11543	0.8427	3	0.4756
Item 26	2.2266	3.2015	1	0.0779	0.0324	0.0445	1	0.8335	0.3814	0.5010	6	0.8053	0.0302	0.0426	1	0.8371	0.80677	1.2067	3	0.3147
Item 27	0.1550	0.2799	1	0.5984	1.0708	2.0280	1	0.1589	0.3142	0.5510	6	0.7674	0.3447	0.6437	1	0.4251	0.82152	1.5163	3	0.2188
Item 28	0.0017	0.0025	1	0.9604	3.7263	5.9342	1	0.0174	0.5205	0.7847	6	0.5852	0.4097	0.5882	1	0.4458	0.58555	0.9055	3	0.4435
Item 29	0.0212	0.0541	1	0.8167	0.7854	2.0109	1	0.1606	0.5694	1.7091	6	0.1335	0.0717	0.1877	1	0.6662	0.4659	1.1719	3	0.3274

Additional file 5

Differential item functioning (DIF) analysis B

	DIF by Sex (M vs F) = Not significant				DIF by Age (62 vs 63+) = Not significant				DIF by education level (7 levels) = Not significant				DIF by disease duration (9 vs 10+) = Not significant				DIF by disease subgroup (lSSc/dSSc/uSSc/Unknown) = Not significant			
Domain	**MS**	**F**	**DF**	**p-value***	**MS**	**F**	**DF**	**p-value***	**MS**	**F**	**DF**	**p-value***	**MS**	**F**	**DF**	**p-value***	**MS**	**F**	**DF**	**p-value***
Function	0.19281	0.21226	1	0.6465	4.80378	5.37441	1	0.0235	0.564	0.65788	6	0.6837	0.99794	1.06801	1	0.305112	0.51055	0.57742	3	0.632022
Emotional	0.16277	0.26736	1	0.6068	1.22602	2.0194	1	0.1601	0.7317	1.22829	6	0.3055	1.08488	1.8127	1	0.182934	0.14922	0.23207	3	0.873683
Sleep	0.09851	0.08185	1	0.7756	0.17544	0.14115	1	0.7083	0.82312	0.65447	6	0.6864	0.19451	0.15662	1	0.693511	1.86525	1.70591	3	0.174649
Social	0.02278	0.03089	1	0.8610	0.05905	0.08235	1	0.7750	0.13609	0.17504	6	0.9826	0.39224	0.53712	1	0.466264	0.34019	0.43505	3	0.728702
Pain	0.25705	0.39217	1	0.5332	0.74814	1.13911	1	0.2897	0.39402	0.57958	6	0.7451	0.32009	0.48379	1	0.489116	0.83444	1.34318	3	0.268556

DIF, Differential Item Functioning; MS, Mean Square; F, F-Value; DF, degree of freedom; p-value*, Bonferroni adjusted p-value i.e. 0.05/number of tests (items)

Additional file 6

Testing the dichotomized responses (i.e. 'always', 'usually' or 'sometimes'=1, 'never'=0)

Additional file 6A: fit statistics for individual items with dichotomised response structure

Item	Location	SE	FitResid	DF	ChiSq	DF	p-value*
Item 1	0.363	0.315	0.709	68.5	1.806	1	0.178969
Item 2	2.18	0.4	-0.432	68.5	0.723	1	0.395106
Item 3	-0.097	0.311	-0.249	66.6	0.099	1	0.753411
Item 4	-0.004	0.311	0.474	67.55	1.362	1	0.243172
Item 5	1.475	0.353	0.57	68.5	1.069	1	0.301237
Item 6	-0.021	0.312	0.369	66.6	0.318	1	0.57284
Item 7	0.236	0.313	0.161	67.55	1.279	1	0.258149
Item 8	-0.019	0.312	-1.245	67.55	0.676	1	0.411119
Item 9	-0.028	0.312	-1.215	67.55	0.676	1	0.410891
Item 10	-0.134	0.311	0.132	67.55	0.152	1	0.696616
Item 11	0.186	0.312	-0.9	68.5	1.325	1	0.249663
Item 12	2.569	0.438	0.049	68.5	1.858	1	0.172868
Item 13	0.06	0.314	-1.806	66.6	1.604	1	0.205356
Item 14	1.628	0.367	-0.465	67.55	0.117	1	0.732811
Item 15	0.81	0.331	-1.03	66.6	0.73	1	0.392728
Item 16	-0.329	0.31	0.182	65.65	1.2	1	0.273324
Item 17	0.054	0.314	-1.632	66.6	0.355	1	0.551372
Item 18	1.681	0.37	-0.742	67.55	1.216	1	0.270162
Item 19	-2.29	0.331	-0.989	67.55	4.809	1	0.028316
Item 20	-0.329	0.309	-0.008	67.55	0.052	1	0.819643
Item 21	-2.35	0.335	-1.304	66.6	6.517	1	0.010687
Item 22	0.969	0.335	-0.156	67.55	1.22	1	0.269341
Item 23	1.206	0.34	0.557	67.55	0.564	1	0.452666
Item 24	-2.67	0.346	0.037	66.6	2.775	1	0.095764
Item 25	-2.521	0.342	0.687	67.55	11.357	1	0.000753
Item 26	0.976	0.333	-0.957	67.55	0.756	1	0.384706
Item 27	-1.759	0.32	-1.141	68.5	4.987	1	0.025535
Item 28	-0.846	0.311	-0.007	67.55	0.863	1	0.352842
Item 29	-0.992	0.31	-1.29	68.5	1.734	1	0.187852

Additional file 6B: fit statistics for domains with dichotomised response structure

Domain	Location	SE	FitResid	DF	ChiSq	DF	p-value*
Function	0.618	0.129	0.215	51.65	1.339	1	0.247277
Emotional	-0.075	0.079	-1.05	49.4	0.202	1	0.652785
Sleep	-0.294	0.172	0.236	53.15	0.038	1	0.844455
Social	-0.16	0.109	-0.22	50.15	1.933	1	0.164422
Pain	-0.089	0.19	-0.13	51.65	1.757	1	0.184966

Additional file 7

Scoring instructions for the new German version of the Systemic Sclerosis Quality of Life (SScQoL) questionnaire

How to use and score the German Systemic Sclerosis Quality of Life (SScQoL) tool

Background information

The German SScQoL is a self-administered questionnaire containing 29 items, which measure health-related quality of life of patients with systemic sclerosis (SSc). The statements are grouped into five domains that measure specific aspects of quality of life according to the International Classification of Functioning, Disability and Health (ICF) framework. These are:

1. Function
2. Emotional
3. Sleep
4. Social
5. Pain

Uses of the German SScQoL

The German SScQoL can be used by clinicians in wards or clinics to assess quality of life of individual SSc patients. The SScQoL can also be used to assess quality of life of groups of SSc patients. Here should be considered that the German SScQoL is only validated in Swiss German-speaking patients. Thus, caution is needed when attempting to extend findings to other German-speaking populations. Further studies would need to include patients from Austria, Germany and Liechtenstein to confirm the robustness of the German SScQoL.

How is the German SScQoL completed?

The German SScQoL is designed to be completed by the patient unaided. The 29 statements (items) comprise 4-point response options with the following descriptives: "Always", "Usually", "Sometimes", and "Never". Patients should tick "X" in the box that corresponds with their level of agreement. Only one box should be ticked for each statement.

How the German SScQoL is scored?

The German SScQoL can be used as a tool in clinical practice to evaluate individual patient quality of life or as a research/audit tool to evaluate health related quality of life of groups of patients. Two ways of scores can be used as shown below.

A. The German SScQoL used as a clinical tool

The clinician may want to know how health-related quality of life of a SSc patient is at a particular time, which allows her/him to focus on specific items or overall quality of life during the consultation. Furthermore, quality of life can be assessed again at a follow-up consultation to see changes over time. Therefore, the German SScQoL can be scored as follows:

1. Ich kann nichts tun, ohne vorher gründlich drüber nachzudenken

3	Immer	2	Meistens	1	Manchmal	0	Nie

2. Die Erkrankung ist ständig in meinen Gedanken

3	Immer	2	Meistens	1	Manchmal	0	Nie

3. Ich mache mir Sorgen, dass ich andere Menschen im Stich lasse

3	Immer	2	Meistens	1	Manchmal	0	Nie

4. Mein derzeitiger Gesundheitszustand macht mich wütend

3	Immer	2	Meistens	1	Manchmal	0	Nie

5. Ich rege mich auf, wenn ich etwas nicht mehr tun kann

3	Immer	2	Meistens	1	Manchmal	0	Nie

6. Ich bin oft frustriert

3	Immer	2	Meistens	1	Manchmal	0	Nie

7. Ich kann mich nicht darauf verlassen, wie es mir am nächsten Tag gehen wird

3	Immer	2	Meistens	1	Manchmal	0	Nie

8. Ich fühle mich, als ob ich ständig kämpfen würde

3	Immer	2	Meistens	1	Manchmal	0	Nie

9. Durch meine Erkrankung habe ich Schlafstörungen

3	Immer	2	Meistens	1	Manchmal	0	Nie

Subtotal Seite 1_____

10. Die Erkrankung beeinträchtigt mein Sozialleben sehr

3	Immer	2	Meistens	1	Manchmal	0	Nie

11. Die Erkrankung hat Einfluss auf das Befinden der Menschen in meinem Umfeld

3	Immer	2	Meistens	1	Manchmal	0	Nie

12. Meine Hände funktionieren nicht mehr so gut wie früher

3	Immer	2	Meistens	1	Manchmal	0	Nie

13. Die Erkrankung belastet meine persönlichen Beziehungen

3	Immer	2	Meistens	1	Manchmal	0	Nie

14. Ich muss mich häufiger ausruhen

3	Immer	2	Meistens	1	Manchmal	0	Nie

15. Jede Art von Tätigkeit ist mit Schwierigkeiten verbunden

3	Immer	2	Meistens	1	Manchmal	0	Nie

16. Ich vermeide gewisse gesellschaftliche Situationen, um mich nicht in Verlegenheit zu bringen

3	Immer	2	Meistens	1	Manchmal	0	Nie

17. Ich nehme mir Dinge zu Herzen, die mich früher nicht bedrückt hätten

3	Immer	2	Meistens	1	Manchmal	0	Nie

18. Das Leben ist einfach nicht mehr wie früher

3	Immer	2	Meistens	1	Manchmal	0	Nie

19. Ich komme überhaupt nicht zurecht

3	Immer	2	Meistens	1	Manchmal	0	Nie

20. Schlecht zu schlafen beeinträchtigt mich sehr

3	Immer	2	Meistens	1	Manchmal	0	Nie

21. Ich fühle mich sehr isoliert

3	Immer	2	Meistens	1	Manchmal	0	Nie

_____ **Subtotal Seite 2**

22. Hausarbeiten können ein Problem sein

3	Immer	2	Meistens	1	Manchmal	0	Nie

23. Ich musste einige meiner Hobbies aufgeben

3	Immer	2	Meistens	1	Manchmal	0	Nie

24. Ich fühle mich schuldig, krank zu sein

3	Immer	2	Meistens	1	Manchmal	0	Nie

25. Ich habe Schwierigkeiten mich selbst so zu waschen, wie ich gerne möchte

3	Immer	2	Meistens	1	Manchmal	0	Nie

26. Die Schmerzen schränken mich in meinem Handeln ein

3	Immer	2	Meistens	1	Manchmal	0	Nie

27. Ich fühle mich hilflos

3	Immer	2	Meistens	1	Manchmal	0	Nie

28. Die Schmerzen laugen mich aus

3	Immer	2	Meistens	1	Manchmal	0	Nie

29. Ich vermisse es, meine Angelegenheiten selbst erledigen zu können

3	Immer	2	Meistens	1	Manchmal	0	Nie

_____ **Subtotal Seite 3**

_____ **Subtotal Seite 2**

_____ **Subtotal Seite 1**

_____ **TOTAL (von insgesamt 87 Punkten)**

B. The German SScQoL used as a survey or research tool (scored dichotomously)

For use in audit or research, the German SScQoL needs to be coded and scored using the following steps:

a) The German SScQoL scales descriptives should be number-coded thus:

Immer	= 1
Meistens	= 1
Manchmal	= 1
Nie	= 0

See example below:

Ich habe Schwierigkeiten mich selbst so zu waschen, wie ich gerne möchte

1	Immer	1	Meistens	1	Manchmal	0	Nie

Die Schmerzen schränken mich in meinem Handeln ein

1	Immer	1	Meistens	1	Manchmal	0	Nie

b) Following the coding, adding up all the item scores gives the total German SScQoL score (range = 0–29).

Important remark:

Comparisons with data collected with other SScQoL language versions should be avoided unless further cross-cultural validity tests are done to assess measurement equivalence of the German SScQoL with other language versions and thus enable multinational comparisons and data pooling.

The SScQoL should be cited using the following validation studies:

1. Ndosi M, Alcacer-Pitarch B, Allanore Y, et al. Common measure of quality of life for people with systemic sclerosis across seven European countries: a cross-sectional study. Annals of the Rheumatic Diseases 2018;77:1032-1038.
2. Kocher A, Ndosi M, Denhaerynck K, et al. A rare disease patient-reported outcome measure: revision and validation of the German version of the Systemic Sclerosis Quality of Life Questionnaire (SScQoL) using the Rasch model. *Orphanet Journal of Rare Diseases* 2021;16(1):356. doi: 10.1186/s13023-021-01944-9

Chapter 5 Patient Assessment Chronic Illness Care (PACIC) and its associations with quality of life among Swiss patients with systemic sclerosis – a mixed methods study

Agnes Kocher [1,2]; Michael Simon [1,2]; Andrew A. Dwyer [3,4]; Catherine Blatter [1]; Jasmina Bogdanovic [1]; Patrizia Künzler-Heule [1,5]; Peter M. Villiger [6], Diana Dan [7]; Oliver Distler [8]; Ulrich A. Walker [9]; Dunja Nicca [1,10]

[1] Institute of Nursing Science (INS), Department Public Health (DPH), Faculty of Medicine, University of Basel, Switzerland

[2] Department of Nursing, Inselspital, Bern University Hospital, University of Bern, Switzerland

[3] Boston College, Connell School of Nursing, Chestnut Hill, Massachusetts, USA

[4] Massachusetts General Hospital Munn Center for Nursing Research, Boston, Massachusetts, USA

[5] Department of Gastroenterology/Hepatology and Department of Nursing, Cantonal Hospital St. Gallen, Switzerland

[6] Medical Center Monbijou, CH-3011 Bern, Switzerland

[7] Service of Rheumatology, Lausanne University Hospital, University of Lausanne, Lausanne, Switzerland

[8] Department of Rheumatology, University Hospital Zurich, Zurich, University of Zurich, Switzerland

[9] Department of Rheumatology, University Hospital Basel, Basel, Switzerland

[10] Department of Global and Public Health, Institute for Epidemiology, Biostatistics and Prevention, University of Zurich, Switzerland

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5.1 Abstract

Objectives

We engaged patients living with systemic sclerosis (SSc) to assess current care according to the Chronic Care Model (CCM) from the patient perspective and their health-related quality of life.

Methods

We employed an explanatory sequential mixed methods design. First, we conducted a cross-sectional quantitative survey (n=101) using the Patient Assessment of Chronic Illness Care (PACIC) and Systemic Sclerosis Quality of Life (SScQoL) questionnaires. Next, we conducted qualitative patient interviews (n=4) and a focus group (n=4).

Results

Mean overall PACIC score was relatively low, 3.0 out of a maximum score of 5 (95% CI: 2.8–3.2, n= 100), indicating care was 'never' to 'generally not' aligned with the CCM. Lowest PACIC subscale scores related to 'goal setting/tailoring' (mean = 2.5, 95% CI: 2.2–2.7) and 'problem solving/contextual

counselling' (2.9, 95% CI: 2.7–3.2). No significant correlations were identified between the mean PACIC and SScQoL scores. Interviews revealed patients frequently encounter major shortcomings in care such as '*experiencing organized care with limited participation', 'not knowing which strategies are effective or harmful' and 'feeling left alone with disease and psychosocial consequences'*. Accordingly, patients responded to challenges by *'dealing with the illness in tailored measure', 'taking over complex coordination of care' and 'relying on an accessible and trustworthy team'*.

Conclusions

Key elements of chronic care are not yet systematically implemented in SSc management. We identify gaps in shared decision-making, goal-setting and individual counselling – essential aspect supporting patient self-management skills. Furthermore, there is a lack of complex care coordination tailored to individual patient needs.

KEYWORDS

Systemic sclerosis; Health services research; Outcome and Process Assessment, Health Care; Nursing

5.2 Key messages

What is already known about this subject?

- The variability in disease presentation and symptom burden of patients living with systemic sclerosis (SSc) requires a chronic care approach that includes competent, coordinated, multidisciplinary collaboration as well as self-management support targeting individual patient needs.
- The Chronic Care Modell (CCM) is a longstanding and widely adopted model used to guide chronic illness management. However, little is known about how CCM elements are implemented in SSc care and how patients' care experiences relate to their quality of life.

What does this study add?

- Quantitative findings reveal relatively low patient ratings of chronic care ('never' to 'generally not' aligned with the CCM). Patient ratings of chronic care were not correlated with quality of life.
- Quantitative and qualitative findings highlight the need for shared decision-making, goal-setting, tailored counselling and re-envisioning traditional on-site peer support groups and consultations to better support patients to develop their self-management skills. New models of care should focus on coordinating complex care including ongoing patient follow-up and shared patient-professional leadership roles.

How might this impact on clinical practice or future developments?

- This study informs integrated care models for SSc which need to empower patients and professionals for shared decision-making, co-management of the disease and address psychosocial disease consequences. Strategies and technologies that connect expert knowledge and incorporate community-based resources (i.e., peers) need to be fostered.

5.3 Background

Systemic sclerosis (SSc) is a rare multisystemic, autoimmune connective-tissue disease characterized by a chronic and frequently progressive disease course. Approximately 20 in 100'000 adults are affected.[1, 2] Variability in disease severity, progression, and organ involvement challenge timely diagnosis and effective disease management contributing to high mortality.[1, 3] Approximately 75% of patients develop organ involvement within the first five years of diagnosis and early manifestations including skin fibrosis (75%), gastrointestinal symptoms (71%), lung involvement (65%), digital ulcers (34%) and cardiac involvement (32%).[3] Except for haematopoietic stem cell transplantation for patients with rapidly progressive dcSSc and a high risk of organ failure in an early disease stage, treatments modifying the overall disease course are not available.[4, 5] Thus, medical management must be tailored to individual organ sequelae and disease progression, i.e., regular multidisciplinary consultations to identify organ involvement early as well as pharmacological and non-pharmacological interventions to decrease/slow disease progression and reduce organ damage.[4]

At the same time, interventions need to focus on improving health-related quality of life (HRQoL) of people living with SSc.[6] Over the disease trajectory, patients experience multiple physical and psychosocial problems including fatigue, hand stiffness, Raynaud's phenomenon, digital ulcers, shortness of breath, pain, gastrointestinal symptoms, work disability, depression, anxiety (e.g., fear of disease progression), and dissatisfaction with body image.[6-10] Numerous studies report severely impaired physical and psychological HRQoL in SSc.[10-13] Importantly, the heterogeneous disease presentation and the symptom burden of patients living with SSc necessitate a chronic care approach including competent, coordinated, multidisciplinary collaboration as well as self-management support targeting individual patient needs.[14-17] However, prevailing models of SSc care mainly focus on acute health problems and often lack an integrated approach that addresses the complex care needs of patients.[18, 19]

The Chronic Care Model (CCM) is a longstanding and widely adopted model that includes eHealth approaches to guide chronic illness management.[19-21] The model aims to improve health outcomes through effective and productive interactions between prepared, proactive practice teams and informed, activated patients. The CCM focuses on the six core elements: community resources, health system, self-management support, delivery-system design (e.g., continuity of care), decision support, and clinical information systems. A significant body of literature supports that incorporating CCM elements (e.g. self-management support, clinical decision support) into care is associated with better clinical outcomes including reduced health service use, fewer emergency department visits and lower healthcare costs.[22-24] The Patient Assessment of Chronic Illness Care (PACIC) is a validated tool to assess implementation of the CCM from the patient perspective.[25] Notably, several studies have shown that perceived level of chronic illness management (as measured by the PACIC) is positively correlated with patient outcomes.[26-28] For example, in diabetes, higher PACIC scores are associated with improved markers of glycemic control, self-management activities, physical activity and diminished distress.[29, 30] In transplant patients, higher perceived levels of chronic illness management are positively associated with treatment satisfaction and trust in the transplantation team.[31]

In the rare disease space, few care models incorporate elements of the CCM.[32-34] On average, rare disease patients reported PACIC score of 2.5 (on a 5-point Likert scale ranging from 1='never' to 5='always'), suggesting poorer healthcare experiences compared to reports in patients with common chronic conditions (range 1.7–4.2/5.0).[26, 35-37] In relation to SSc, the association between healthcare provision and rare disease patient outcomes (e.g., HRQoL) has remained unexplored. However, the PACIC is a

generic instrument that may not address specific challenges of rare disease care (e.g., lack of treatment options and specialized healthcare) or specific patient needs regarding heterogeneity/severity of SSc. Accordingly, SSc patient experiences of chronic care in relation to the PACIC dimensions may demand further inquiry using qualitative methods.

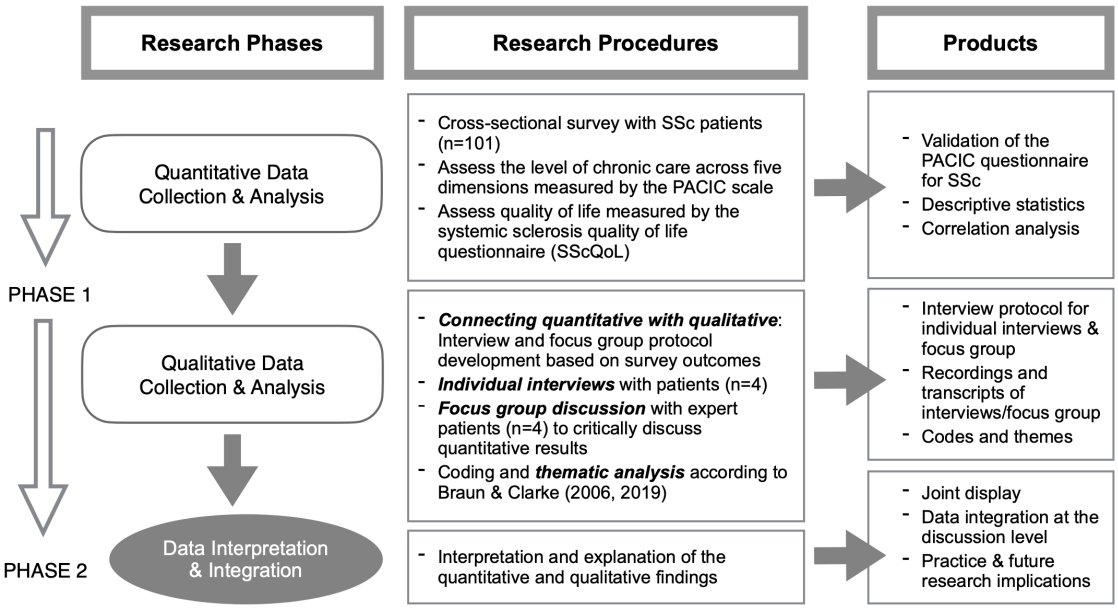
To date, there is paucity of evidence on how CCM elements are implemented in SSc management and how patients' care experiences relate to HRQoL. The MANagement Of Systemic Sclerosis (MANOSS) project aims to fill existing gaps in SSc care by developing an eHealth-enhanced rare disease chronic care model for SSc patients in Switzerland.[38] As part of the MANOSS project, this mixed methods (quantitative and qualitative) study aimed to describe the current state of SSc chronic illness care and HRQoL from the patient perspective to inform the development of an integrated model of care for SSc. The quantitative phase evaluated the level of chronic care across the five dimensions measured by the PACIC scale and quality of life measured by the Systemic Sclerosis Quality of Life Questionnaire (SScQoL). The subsequent qualitative phase aimed to explain care experiences of people living with SSc with a focus on the PACIC dimensions.

5.4 Methods

5.4.1 Study design

The study employed an explanatory, sequential, mixed methods design.[38, 39] Briefly, we first conducted a quantitative cross-sectional survey of Swiss SSc patients (see **Figure 1**). Quantitative analyses informed subsequent qualitative interviews. For qualitative interviews, we used a purposefully selected sub-sample of patients based on the maximum variation of PACIC/HRQoL score to better understand and explain quantitative findings. Ethical approval was obtained for the overall MANOSS project by the responsible Swiss ethics committee (EKNZ 2018-01206).

Figure 1. Study diagram for the explanatory, sequential mixed methods design



5.4.2 Quantitative data collection and analysis

Sample and setting

For the quantitative survey, we recruited a convenience sample of 101 adult patients (>18 years) spanning a range of SSc disease severity and experiences. We recruited German- and French-speaking participants from all Swiss University Hospitals, rheumatology outpatient clinics, and the Swiss scleroderma patients' association (www.sclerodermie.ch) according to the MANOSS study protocol.[38]

Variables and measurement

Patients participating in the MANOSS cross-sectional survey (March – August 2019) completed three survey instruments (paper or web-based format).[38] We used the validated 20-item PACIC instrument to measure care alignment with CCM. The PACIC includes five subscales addressing specific domains: i) patient activation; ii) delivery system design/decision support; iii) goal setting/tailoring; iv) problem solving/contextual counselling; and v) follow-up/coordination.[25] Patients rated care received from their healthcare team (e.g., physicians, nurses, physiotherapists, occupational therapists, social workers) during the past 6-months using a 5-point Likert scale (1='never' to 5='always'). Total and subscale scores are averaged across items. The 20-item PACIC demonstrates reasonable validity and reliability, including high internal consistency ($\alpha = 0.93$), in patients with chronic conditions across many languages and countries when using a single-dimension structure.[25, 40, 41] However, several studies have revealed high inter-correlations between PACIC subscales and 'lack of fit' using the 5-dimension structure – suggesting that subscales may not always be appropriate.[40-42]

We used the revised German and French 29-item Systemic Sclerosis Quality of Life (SScQoL) questionnaire to measure HRQoL.[43, 44] The revised German SScQoL employs a 4-point response structure ('Always', 'Usually', 'Sometimes', 'Never') and is a valid, reliable measure.[44] The response structure of the French version was adapted according to the German version to ensure interoperable responses for the MANOSS survey (German: $\alpha = 0.97$, French: $\alpha = 0.91$).[44, 45] To calculate the overall SScQoL sum score, responses are dichotomized ('Always'=1, 'Usually'=1, 'Sometimes'=1, 'Never'=0) and summed. Higher values indicate lower HRQoL.[44]

We assessed self-reported comorbidities using the 12-item Self-Administered Comorbidity Questionnaire (SCQ) that is moderately to strongly correlated with a standard medical record-based comorbidity measure (i.e., Charlson Index).[46] Patients with SSc often struggle to distinguish between disease-related organ involvement and comorbidities unrelated to SSc. Thus, we used the SCQ to comprehensively assess self-reported comorbidity (i.e., co-occurring diseases in an individual).[47, 48] Participants provided sociodemographic data (sex, age, education, employment status), disease information (subset: lSSc, dSSc, Overlap syndrome or unknown) and disease duration.

Validation of the PACIC questionnaire for SSc

Because PACIC has not been used in the context of SSc, we used the Mokken model to test the construct validity of the PACIC scale and its subscales.[49] Briefly, a scalability (*H* coefficient) value of ≥ 0.50 is considered 'strong', 0.40–0.49 = "moderate" and 0.30–0.39 = 'weak', and values < 0.30 are not considered unidimensional. Scalability for the global PACIC scale was "moderate" (0.46), with several 'weak' items (*H* coefficient below 0.4) (**Supplementary material 1a**). When items were grouped in respective subscales *H* coefficients were 'strong' in four subscales ('patient activation' [0.66], 'delivery system design' [0.60], 'goal setting' [0.50], 'problem solving' [0.67]), while 'follow-up/coordination' had 'moderate' scalability (0.42) (**Supplementary material 1b**). After excluding the problematic items of the

'goal setting' subscale (items 10 and 11) and 'follow-up/coordination' subscale (items 16, 17, 18), *H* coefficients were 'strong' for the subscales (0.69 and 0.70 respectively) and the global scale (0.52) suggesting a robust unidimensional scale (**Supplementary material 2**).

Quantitative data analysis

Quantitative data are reported using descriptive statistics (frequencies/percentages or means/medians with 95% confidence intervals and interquartile ranges) (R, Version 3.6.3, and DescTools-package).[50] To compare PACIC-15 mean scores between groups (e.g., sex, age groups, education, comorbidities), we computed standardized mean differences (SMD) – which are identical to Cohen's *d* (tableone-package for R).[51] Compared to *p* values, SMD is more appropriate for calculating effect size estimates in small, uneven datasets – such as the ones analysed in this study.[52] A SMD ≥ 0.2, ≥ 0.5 and ≥ 0.8 depict small, medium and large differences between groups respectively. We calculated 95% confidence intervals (CIs) for means to facilitate comparison between ratings. Differences between groups were defined as means with distinct, non-overlapping CIs. Correlation analysis (pearson's *r)* was computed to calculate associations between PACIC and SScQoL levels and visualized using the corrplot-package in R.[53]

5.4.3 Qualitative data collection and analysis

Sample and setting

To further explore the association between HRQoL and perception of chronic care, we used data from individual patient interviews (n=4) and one patient focus group (n=4), that were conducted within the larger qualitative *MANOSS* study (i.e., n=14 individual interview and n=17 focus group participants). Individual interview participants were purposefully selected from the quantitative *MANOSS* study sample according to patients' PACIC and SScQoL scores (**Table 1**). For the focus group, we contacted patients with experience living with SSc (i.e., disease duration >10 years) from the Swiss Scleroderma Association and the quantitative study sample.

Data collection

Semi-structured individual interviews were conducted in German, French or English and were conducted (30-90 minutes in duration) either on-site or via telephone (due to COVID-19 pandemic restrictions).[38] Open-ended interview questions (e.g., How do you experience your care? What would the best possible care look like for you?) were drawn from the CCM and patient's narratives.[20, 38] The complete interview guide is published in the MANOSS study protocol.[38] Interviews were recorded and transcribed verbatim.

Focus group participants (n=4) were engaged using an interview guide with open-ended prompts to discuss our quantitative study results (i.e., What is important/surprising? What fits your experience? What contradicts your own experience? What are important aspects that should be taken into account when improving chronic care for patients?). Subsequently, primary care needs and problem areas for care were discussed from a patient perspective. Due to the COVID-19 pandemic, the focus group was conducted using an online video conferencing (Zoom) and recorded with participant consent.

Table 1. *MANOSS* subsample (n=4) classified according to SScQoL and PACIC mean values

Low quality of life (i.e., high SScQoL score) **Low chronic care** (i.e., low PACIC score)	**High quality of life** (i.e., low SScQoL score) **Low chronic care** (i.e., low PACIC score)
Patient 1 QoL: 26 PACIC: 2.2 Gender: female Age: 49 years Disease duration: 37 years Disease subset: dcSSc Number of comorbidities: 3	**Patient 2** QoL: 5 PACIC: 2.5 Gender: female Age: 61 years Disease duration: 2 years Disease subset: lcSSc Number of comorbidities: 1
Low quality of life (i.e., high SScQoL score) **High chronic care** (i.e., high PACIC score)	**High quality of life** (i.e., low SScQoL score) **High chronic care** (i.e., high PACIC score)
Patient 3 QoL: 27 PACIC: 3.8 Gender: female Age: 73 years Disease duration: 13 years Disease subset: dcSSc Number of comorbidities: 6	**Patient 4** QoL: 2 PACIC: 5.0 (many missing values) Gender: female Age: 44 years Disease duration: 7 years Disease subset: unknown Number of comorbidities: 0

Note: dcSSc=diffuse cutaneous systemic sclerosis; lcSSc=limited cutaneous systemic sclerosis; PACIC=Patient Assessment of Chronic Illness Care; SScQoL=Systemic Sclerosis Quality of Life

Qualitative data analysis

We used a reflexive thematic analysis approach described by Braun and Clarke.[54, 55] Briefly, investigators started analysis of interview transcripts by (1) familiarizing themselves with the data (i.e., reading and discussing first impression, main issues from patient perspective), (2) coding the data and developing first patterns of shared meaning across all interviews (i.e., inductive, but not theory free) and (3) constructing patterns/themes to explain PACIC dimensions. Finally, themes were refined and named based on original data (i.e., quotes, codes).

5.4.4 Mixed methods data integration

The quantitative data informed the structure of the qualitative study. Subsequently, the qualitative data were used to explain the quantitative findings. Importantly, the mixed methods approach provides deeper insight for model development than either method in isolation.[39] We present our quantitative results first, followed by a joint display including key quantitative findings and qualitative in-depth themes for each PACIC dimension and data integration at the level of discussion.

5.5 Results

5.5.1 Participants' characteristics

In total, 101 patients (median age = 60 yrs., IQR: 50-68) with a median disease duration of 8 years (IQR: 5-15) completed the survey (**Table 2**). Approximately half of patients (52/101, 51.5%) reported having more than two comorbidities. In total, 8 patients (interview: n=4, focus group: n=4) participated in the qualitative study (**Table 1**). All four focus group participants were active members of a patient organization and three had a medical and/or scientific background.

Table 2. Patient characteristics of quantitative survey

Patients		**Quantitative survey (n=101)**
Sex [n (%)]	Female	77 (76.2%)
	Not reported	4 (4%)
Age (years) [median (IQR)]		60 (50-68)
Disease subset, self-reported [n (%)]	lcSSc	31 (30.7%)
	dcSSc	36 (35.6%)
	Other rare rheumatic disease	3 (3.0%)
	Don't' know	25 (24.8%)
Disease duration (years) [median (IQR)]		8 (5-15)
Comorbidities, self-reported [median (IQR)]		3 (1–4)
Questionnaire [n (%)]	Online survey	43 (42.6%)
	Paper survey	58 (57.4%)
Country/Region of origin [n (%)]	Switzerland (German region)	79 (78.2%)
	Switzerland (French region)	22 (21.8%)
Marital status [n (%)]	Single	13 (12.9%)
	Married/cohabiting	68 (67.3%)
	Divorced, separated or widowed	16 (15.9%)
	Not reported	4 (4%)
Highest educational degree [n (%)]	Tertiary level	37 (36.7%)
	Upper secondary	48 (47.5%)
	Compulsory	13 (12.9%)
	No completed education	1 (1%)
	Not reported	2 (2%)
Employment [n (%)]	Employed	50 (49.5%)
	Full time (80-100%)	22 (21.8%)
	Part time (< 80%)	28 (27.9%)
Reasons for non-employment [n (%)]	Retired	30 (29.7%)
	On disability or sick leave	10 (9.9%)
	In training/student	7 (7%)
	Looking for work	4 (4%)

Note: dcSSc=diffuse cutaneous systemic sclerosis; IQR=interquartile range; lcSSc=limited cutaneous systemic sclerosis; SScQoL=systemic sclerosis quality of life

5.5.2 Patient Assessment of Chronic Illness Care (PACIC) and its associations

The distribution of all PACIC-15 scales in the overall, the German and the French-speaking *MANOSS* sample is presented in **Table 3**. Single item values are presented in **Table 7** (i.e., joint display of quantitative and qualitative findings). The mean overall PACIC-15 score was relatively low ($\bar{x}$=3.0, 95% CI: 2.8–3.2, n=100) indicating that care was 'never' to 'generally not' perceived as aligned with the CCM. Lowest PACIC-15 mean subscale scores related to 'goal setting/tailoring' ($\bar{x}$=2.5, 95% CI: 2.2–2.7, n=99), followed by 'problem solving/contextual counselling' ($\bar{x}$=2.9, 95% CI: 2.7–3.2, n=99). The single PACIC-15 items with the lowest ratings were: 'given a copy of my treatment plan' ($\bar{x}$=2.0, 95% CI:1.7–2.3, n=97) and 'helped to plan ahead so I could take care of my condition(s) even in hard times' ($\bar{x}$=2.5, 95% CI: 2.2–2.8, n=98).

Table 3. Distribution of the 15-item PACIC scale

	PACIC mean scores (95% CI)		
PACIC scales	**Overall (n=101)**	**German sample (n=79)**	**French sample (n=22)**
PACIC 15-item scale summary score (average of all 15 items)	3.0 (2.8–3.2)	3.1 (2.9–3.4)	2.7 (2.2–3.2)
Subscale 1: *Patient activation* *(average of item 1–3)*	3.4 (3.1–3.6)	3.4 (3.2–3.7)	3.0 (2.4–3.6)
Subscale 2: *Delivery system design/ Decision Support* *(average of item 4–6)*	3.2 (3.0–3.4)	3.3 (3.0–3.5)	3.2 (3.0–3.4)
Subscale 3: *Goal setting/ Tailoring* *(average of item 7–9)*	2.5 (2.2–2.7)	2.6 (2.3–2.9)	1.9 (1.4–2.4)
Subscale 4: *Problem solving/ Contextual Counselling* *(average of item 12–15)*	2.9 (2.7–3.2)	3.0 (2.7–3.3)	2.7 (2.1–3.3)
Subscale 5: *Follow-up/ Coordination* *(average of item 19–20)*	3.3 (3.0–3.5)	3.3 (3.0–3.7)	2.9 (2.3–3.6)

Note: CI=Confidence interval; PACIC=Patient Assessment of Chronic Illness Care

Generally, patient characteristics were not associated with mean PACIC-15 scores (**Table 4**). However, patients ≤65 years ($\bar{x}$=3.1 vs. 2.7; SMD=0.41, n=95) and males ($\bar{x}$=3.3 vs. 3.0; SMD=0.33, n=97) reported higher mean PACIC scores. Patients trended towards lower mean PACIC scores early in the disease trajectory (i.e., within two years of diagnosis) ($\bar{x}$=2.9 vs. 3.1; SMD=0.15, n=95) and in subgroup with diffuse cutaneous systemic sclerosis (dcSSc) ($\bar{x}$=2.9 vs. 3.2; SMD=0.26, n=67). Interestingly, patients with lung ($\bar{x}$=3.4 vs. 2.8; SMD=0.61, n=100) and gastrointestinal (GI) problems ($\bar{x}$=3.2 vs. 2.9; SMD=0.29, n=100) reported higher PACIC levels than those without pulmonary/GI comorbidities. Patients with musculoskeletal complaints reported lower PACIC scores (back pain: $\bar{x}$=2.9 vs. 3.2; SMD=0.31, n=97; osteoarthritis: $\bar{x}$=2.8 vs. 3.1; SMD=0.30, n=98). Further, patients with more than two self-reported comorbidities reported lower PACIC levels ($\bar{x}$=2.8 vs. 3.0; SMD=0.28, n=100).

No significant correlations (pearson's *r)* were identified between the mean PACIC-15 and SScQoL scores (neither total score nor sub-dimensions) (**Supplementary material 3**).

Table 4. Univariate analyses of patient characteristics and comorbidities in relation to the mean PACIC-15 score (n=101)

	Characteristics	**Mean PACIC score (95% CI)**	***P* value**	**SMD**
Sex	Male (n=20) Female (n=77)	3.3 (2.8–3.9) 3.0 (2.7–3.2)	0.172	0.326
Age	≤65 years (n=65) >65 years (n=30)	3.1 (2.9–3.4) 2.7 (2.3–3.1)	0.063	0.408
Education	Compulsory/no education (n=14) Secondary/tertiary (n=85)	3.2 (2.4–3.9) 3.0 (2.8–3.2)	0.617	0.133
Marital status	Single, divorced, or widowed (n=29) Married/cohabiting (n=68)	3.2 (2.8–3.6) 2.9 (2.7–3.2)	0.240	0.259
Disease subset	dcSSc (n=36) lcSSc (n=31)	1.9 (2.6–3.2) 3.2 (2.8–3.6)	0.284	0.263
Disease duration	≤ 2 years (n=12) > 2 years (n=83)	2.9 (2.4–3.5) 3.1 (2.9–3.3)	0.637	0.153

Comorbidities*	≤ 2 comorbidities (n=48) > 2 comorbidities (n=52)	3.2 (2.9–3.5) 2.9 (2.6–3.2)	0.176	0.273
Depression*	Yes (n=15) No (n=84)	3.0 (2.4–3.5) 3.1 (2.8–3.3)	0.708	0.107
GI-problems*	Yes (n=60) No (n=40)	3.2 (2.9–3.4) 2.9 (2.5–3.2)	0.149	0.294
Lung problems*	Yes (n=38) No (n=62)	3.4 (3.1–3.7) 2.8 (2.6–3.1)	0.004	0.607
Heart problems*	Yes (n=27) No (n=72)	3.0 (2.6–3.4) 3.0 (2.8–3.3)	0.816	0.053
Backpain*	Yes (n=41) No (n=56)	2.9 (2.6–3.1) 3.2 (2.9–3.4)	0.132	0.315
Osteoarthritis*	Yes (n=41) No (n=57)	2.8 (2.6–3.1) 3.1 (2.9–3.4)	0.151	0.299

Note: *CI=Confidence interval; dcSSc=diffuse cutaneous systemic sclerosis; GI-problems=gastrointestinal problems, lcSSc=limited cutaneous systemic sclerosis; PACIC=Patient Assessment of Chronic Illness Care; SD=Standard deviation; SMD=Standardized mean difference (SMD ≥ 0.2, ≥ 0.5 and ≥ 0.8 depict small, medium and large differences between groups respectively) * self-reported*

5.5.3 Association of HRQoL and patient characteristics/comorbidities

The overall mean SScQoL score was 18.3 (95% CI: 16.7–19.9). Patients from German-speaking Switzerland tended to have better SScQoL outcomes ($\bar{x}$=17.4 vs 21.4; SMD=0.56), particularly in 'emotional' ($\bar{x}$=7.5 vs 9.9; SMD=0.71) and 'sleep' ($\bar{x}$=1.2 vs 1.7; SMD=0.61) dimensions. Younger patients (≤65 years) tended to report poorer HRQoL ($\bar{x}$=19.0 vs 16.6; SMD=0.30) (**Table 5**).

Table 5. Distribution of the 29-item SScQoL scales

SScQoL scales	**SScQoL mean scores (95% CI)**		
	Overall (n=101)	**German sample (n=79)**	**French sample (n=22)**
SScQoL 29-item scale summary score (range 0-29)	18.3 (16.7–19.9)	17.4 (15.5–19.3)	21.4 (19.0–23.8)
Subscale 1. Function (range 0-6)	4.1 (3.8–4.4)	4.0 (3.6–4.4)	4.5 (4.0–5.1)
Subscale 2. Emotional (range 0-13)	8.0 (7.3–8.8)	7.5 (6.6–8.4)	9.9 (8.8–10.9)
Subscale 3. Sleep (range 0-2)	1.3 (1.1–1.5)	1.2 (1.0–1.4)	1.7 (1.4–2.0)
Subscale 4. Social (range 0-6)	3.5 (3.1–3.9)	3.5 (3.0–4.0)	3.7 (2.9–4.6)
Subscale 5. Pain (range 0-2)	1.3 (1.1–1.5)	1.2 (1.0–1.4)	1.6 (1.3–1.9)

***Note*:** CI=Confidence interval; SScQoL=Systemic Sclerosis Quality of Life;

SScQoL answer options are dichotomised for analysis: 'Always', 'Usually', 'Sometimes' = 1; 'Never' = 0; Higher scores indicate a greater impact of the disease, i.e., decrease of health-related quality of life (HRQoL)

Notably, HRQoL was strongly associated with self-reported comorbidities (**Table 6**) but no other patient characteristics. Neither sex, marital status nor disease subset/duration were associated with SScQoL mean score. Patients ≤65 years old ($\bar{x}$=19.0 vs. 16.6; SMD=0.30, n=95) and with compulsory or no education ($\bar{x}$=20.3 vs. 18.0; SMD=0.30, n=99) tended to exhibit lower HRQol (i.e., higher SScQoL scores). The number of patient self-reported comorbidities had a deleterious influence on SScQoL. Patients reporting more than two comorbidities (51.5%, n=52) had lower HRQoL – as evidenced by significantly higher SScQoL score ($\bar{x}$=22.3 vs. 14.3; SMD=1.15, n=100). Similar findings were observed in individuals reporting depression ($\bar{x}$=24.3 vs. 17.4; SMD=1.10, n=99), gastrointestinal problems ($\bar{x}$=21.2 vs. 14.3; SMD=0.94, n=100) and osteoarthritis ($\bar{x}$=21.3 vs. 16.4; SMD=0.64, n=98).

Table 6. Univariate analyses of patient characteristics and comorbidities in relation to the mean SScQoL score (n=101)

	Characteristics	**Mean SScQoL score (95% CI)**	***P* value**	**SMD**
Sex	Male (n=20) Female (n=77)	16.8 (12.7–21.0) 18.6 (16.9–20.4)	0.372	0.216
Age	≤65 years (n=65) >65 years (n=30)	19.0 (17.1–21.0) 16.6 (13.6–19.6)	0.169	0.304
Education	Compulsory/no education (n=14) Secondary/tertiary (n=85)	20.3 (16.5–24.0) 18.0 (16.3–19.8)	0.328	0.306
Marital status	Single, divorced, or widowed (n=29) Married/cohabiting (n=68)	17.3 (14.1–20.5) 18.9 (17.1–20.8)	0.374	0.194
Disease subset	dcSSc (n=36) lcSSc (n=31)	20.9 (18.6–23.2) 18.7 (15.7–21.7)	0.232	0.294
Disease duration	≤ 2 years (n=12) > 2 years (n=83)	18.6 (13.0–24.2) 19.0 (17.4–20.7)	0.858	0.052
Comorbidities*	0-2 comorbidities (n=48) > 2 comorbidities (n=52)	14.3 (12.1–16.6) 22.3 (20.6–24.0)	<0.001	1.147
Depression*	Yes (n=15) No (n=84)	24.3 (22.3–26.4) 17.4 (15.6–19.2)	0.002	1.097
GI-problems*	Yes (n=60) No (n=40)	21.2 (19.6–22.9) 14.3 (11.6–17.0)	<0.001	0.937
Lung problems*	Yes (n=38) No (n=62)	19.6 (17.2–22.0) 17.8 (15.6–19.9)	0.262	0.236
Heart problems*	Yes (n=27) No (n=72)	20.0 (17.2–22.9) 17.8 (15.8–19.7)	0.204	0.296
Backpain*	Yes (n=41) No (n=56)	20.7 (18.2–23.2) 16.8 (14.7–18.9)	0.018	0.496
Osteoarthritis*	Yes (n=41) No (n=57)	21.3 (19.0–23.6) 16.4 (14.3–18.5)	0.002	0.643

Note: CI=Confidence interval; dcSSc=diffuse cutaneous systemic sclerosis; GI-problems=gastrointestinal problems, lcSSc=limited cutaneous systemic sclerosis; SScQoL=Systemic Sclerosis Quality of Life; SD=Standard deviation; SMD=Standardized mean difference; * self-reported

5.5.4 Qualitative findings

The quantitative findings informed the structure of the qualitative data description – presented in a joint display (**Table 7**). More concrete, patient experiences with the current chronic care approach are described in six themes illustrated with patient quotes. Whereas always two qualitative themes are mapped to the PACIC dimensions: (1) 'experiencing organized care with limited participation' and (2) 'dealing with the illness in tailored measure' (belonging to 'patient activation' and 'delivery system design/decision support'); (3) 'not knowing which strategies are effective or harmful' and (4) 'feeling left alone with disease and psychosocial consequences' (belonging to 'goal setting/tailoring' and 'problem solving/contextual counselling'); (5) 'taking over complex coordination of care' and (6) 'relying on an accessible and trustworthy team' (belonging to 'follow-up/coordination'). In respect to **Table 7**, the reader is advised to start with the dimension definition, then the overview of the quantitative results followed by the qualitative results to better understand the patient experience.

Table 7. Joint display of key quantitative findings for each PACIC subscale and interrelated qualitative themes

Main quantitative results	Description of qualitative themes and quotes
PACIC dimension: Delivery System Design / Decision Support *Definition:* Actions that organize care and provide information to patients to enhance their understanding of care ***PACIC dimension: Patient Activation*** *Definition*: Actions that solicit patient input and involvement in decision-making	
Delivery System Design / ***Decision Support*** (item 4–6) - Most patients were satisfied with overall organisation of care (Item 5: $\bar{x}$=3.9, 95% CI: 3.7-4.1) - Nevertheless, only 29% of patients (always/most of the time) received a written list of things they should do to improve their health (Item 4: $\bar{x}$=2.6, 95% CI: 2.3–2.8) - Only 37% were (always/most of the time) shown how their self-management strategies influenced their condition (Item 6: $\bar{x}$=3.1, 95% CI: 2.8–3.3) - Differences in reported PACIC levels were found according to patient comorbidities. Patients with lung problems reported the highest mean PACIC levels ($\bar{x}$=3.2, CI: 2.9–3.5), while lower levels were found in those with more than 2 comorbidities ($\bar{x}$=2.8, CI: 2.5–3.0).	****Theme 1. Experiencing organized care with limited participation*** *describes SSc patients' experiences with care delivery and shared decisions* - Participants appreciated regular medical check-ups (approx. every 1-2 years), but feared negative results. Those with an early/mild form of SSc sometimes doubted the necessity of such expensive examinations. *«The examinations were really stressful. The organization was super, but I thought, hopefully they won't find anything. The more examinations there are, the sicker you feel. I thought, I just have to hang in there. But I asked myself later if that was really necessary. If they don't find anything, fine – but it still costs a lot. It's contradictory, or..?!» (Patient 4, interview)* - Participants reported limited own participation during consultations/check-ups. They all reported to be able to ask questions, but in their perception, it was the healthcare team that made the decisions. *«Later, the (health care professionals) talked among themselves and reached an agreement, then I was asked to join them and was informed. That's good in principle, then I can ask questions or learn what's going to be done next.» (Patient 1, interview)* - Participants experienced that their own self-management strategies were not specifically valued or integrated by healthcare professionals (HPs). Some reported being afraid to inform physicians about strategies such as complementary therapies or felt not taken seriously if they did. *«I noticed myself that it's hard to contribute during the examination. For about 10 years I didn't dare to say I take Vitamin D. And now I also take B-Vitamins.» (Patient focus group)* - One patient described her experiences with one-to-one peer support as very supportive in the decision-making process for a possible lung transplantation. *«Lung transplantation was being considered for me. I could talk to two people who had been through that. With one person in a one-to-one telephone call and I met the other personally. I got a lot out of it because it was possible to talk about personal problems and ask questions. You don't dare do that in a group.» (Patient 2, interview)*

Patient Activation (item 1–3) *Quantitative results*: 27-31% of patients with SSc were never/generally not asked for their ideas when a treatment plan was made nor given choices about treatment to think about (Item 1: $\bar{x}$=3.6, 95% CI: 3.3–3.8, Item 2: $\bar{x}$=3.2, 95% CI: 2.9–3.4) - Only half of patients were (always/most of the time) asked to talk about their problems with medicines or their effects (Item 3: $\bar{x}$=3.4, 95% CI: 3.1–3.6)	****Theme 2. Dealing with the illness in tailored measure*** *describes patients being overwhelmed and protecting themselves from constant confrontation with their disease* - Participants reported being overwhelmed with the disease information they received just after diagnosis, especially when it came in a written form without much explanation and the possibility to ask questions. *«I had questions (about the disease) and since I knew nothing about it, he (doctor) just gave me a brochure. I knew I have a limited system sclerosis, but [the brochure] described really everything horrible and that scared me even more. It was terrible. I felt awful for a while and didn't read anything more. I had first to get over the shock.» (Patient 2, interview)* - Participants who did not experience their symptoms as part of a severe disease, especially if the symptoms were only mild, did not want to deal with examinations and possible disease consequences, which have not yet occurred. Nevertheless, several emphasized the need for a step-wise learning process oriented toward progression of their own illness. *«I try to live as normally as possible. That's why I don't do some things that make me feel sick (for example, examinations) even if that that overtaxes me sometimes. I like it when I can solve something myself or can call in if something is wrong.» (Patient 1, interview)* - Participants in a later disease stage described how they protect themselves from a constant confrontation with the disease by a reduction of medical consultations and examinations or by limiting them to a certain period of time. Those with extensive expertise reflected that for optimal patient activation, health care professionals have to tailor information and provide support according to an individual patient's disease stage and readiness. *«At the beginning, you really need support from other people. Later there's a phase where you can manage the situation yourself. But later, you reach another point where you just can't cope, because this happens or that turns up. I am now at a point where I have lost the orientation. I don't know any more what I should do, or which doctor I should see. Then you need support again. What you need differs and it's really hard for the health care professionals. The only solution is talk to one another and find out what is difficult for the person and what can be done about it. Just general strategies don't work.» (Patient focus group)*
PACIC dimension: Goal setting / Tailoring *Definition:* Acquiring information for and setting of specific, collaborative goals ***PACIC dimension: Problem-solving / Contextual Counselling*** *Definition:* Considering potential barriers and the patient's social and cultural environment in making treatment plans	
Goal setting / Tailoring (Item 7–11) *Quantitative results:* - 73% of patients never/generally not received a copy of their treatment plan (Item 9: $\bar{x}$=2.0, 95% CI: 1.7–2.3)	****Theme 3. Not knowing which strategies are effective or harmful*** *describes the lack of guidance for independent self-management by patients* - Participants described that they lacked guidance and exchange with health care professionals on self-management strategies to maintain their health and well-being, not only during and after diagnosis, but also later when they were already considered 'experienced' patients. *«I always had the feeling that the answer (from the doctor about what one can do oneself) was that the course of the disease is very individual and for that reason, there is no general answer. That doesn't really help and I said to myself: OK, I'll just leave it.» (Patient 2, interview)*

- 60% were never/generally not encouraged to go to a patient support group or class (Item 10: $\bar{x}$=2.3, 95% CI: 2.0–2.6) - Almost half of patients were never/generally not asked to talk about their self-management goals (43%) or helped to set specific goals to improve their eating or exercise (47%) (Item 7: $\bar{x}$=2.8, 95% CI: 2.5–3.0, Item 8: $\bar{x}$=2.6, 95% CI: 2.4–2.9) - 22% were never/generally not asked questions about their health habits (e.g., risk factors such as smoking) (Item 11: $\bar{x}$=3.6, 95% CI: 3.3–3.9)	- Participants explained that even when self-management strategies were recommended by professionals, as for example to improve physical activity, they often felt lost with respect to planning and evaluating these activities. Even participants spending time searching for appropriate information reported difficulties in adapting the information they found. *«They never told me what I really should do with the crosstrainer or the bicycle in reference to me specifically, how long, at what level, at what watt setting. I'm sorry about that, because I really don't know whether I do too much or too little. It would also help as motivation to training. I don't even know if it would be noticed, if I didn't go there.» (Patient 1, interview)* - Some participants questioned the strong focus on medical outcomes, such as lab or examination results, to evaluate their health and well-being. In particular experienced patients emphasized the importance of patient- experienced outcomes as a focus of care, to prevent anxiety and insufficient self-management in patients. *«The question is also: "Who defines the outcomes?" When the doctor looks at the values and says: "Super! It's stayed the same, the blood value is good! That's good, I am satisfied." But the patient feels worse. Yeah, what happens then?» (Patient focus group)*
	4. Feeling left alone with disease and psychosocial consequences *describes the difficulties of dealing with disease consequences that are rarely addressed by HPs*
Problem-solving / Contextual Counselling (Item 12–15) *Quantitative results:* - 57% of patients were (always/most of the time) sure that their doctor or nurse thought about their values and traditions when recommending a treatment (Item 12: $\bar{x}$=3.5, 95% CI: 3.3–3.8) 55% were never/generally not helped to plan ahead to take care of their condition(s) even in hard times (Item 14: $\bar{x}$=2.5, 95% CI: 2.2–2.8), nor were they helped to make a treatment plan that for their daily life (48%, Item 13: $\bar{x}$=2.7, 95% CI: 2.4–3.0) - 15% (n=15) reported having a depression in the last year	- Participants reflected on their difficulties to address negative emotions and social problems with health professionals. They reported feelings of shame or just did not expect support from professionals. Especially patients in the early stages of the disease described how they isolated and tried to cope with negative emotions by themselves. *«You isolate yourself in shock and in fear of what can happen. And then there is self-stigmatization. You think you're alone in the world with this disease. And the professionals can't help you, although they know everything.» (Patient focus group)* - Participants revealed that psychosocial consequences such as depressive symptoms or financial problems were not systematically addressed by professionals. Several patients reported that they suffered from problems of feeling down, sleeplessness or financial worries over longer time periods and had not been asked about these by professionals. *«What was my experience? Well, definitely not thorough, that someone (professional) said, so let's sit down and talk about you and your situation, what effects this might have (..) In fact, my husband was the one who suffered most, who had to put up with everything I couldn't explain. This despair: Now I am really sick and there is no cure and that's terrible. And the sleeplessness and all these things, he had to put up with them. It certainly wasn't an easy time for him.» (Patient 2, interview)* - «Participants emphasised the importance of having at least one trustworthy person to talk to about their daily concerns related to their disease. Some did not want to burden their relatives with these worries or did not feel understood by them and sought professional help themselves by consulting a psychologist or psychotherapist. *«I can't really talk about this at home. They don't understand. That's why I think psychological help is important, to get this off my chest. It's not about finding new strategies to do things better, it's about the everyday burden, everyday worries.» (Patient 1, interview)* - Participants did not perceive self-help groups as a source of support for problem solving. Whereas some felt they were still 'too healthy' to join such a group, others experienced participation as additional emotional strain on them. For example, because of moaning by others. Given the variety of disease representations and experiences, focus group participants discussed the limitations of traditional self-help groups for people with SSc.

	«It doesn't help. I come out of there and say, how can one ever be so taken by yourself, by the disease, that that's the main topic in life. It is often very extreme, when you always hear the same thing at every meeting, I just have to say, that's too much for me.» (Patient 1, interview)
PACIC dimension: Follow-up / Coordination *Definition:* Arranging care that extends and reinforces office-based treatment, and making proactive contact with patients to assess progress and coordinate care	
Follow-up / Coordination *Definition:* (Item 16–20) *Quantitative results:* - 69% were never/generally not encouraged to attend programs in the community (Item 17: $\bar{x}$=1.9, 95% CI: 1.7–2.1) - 64% were never/generally not contacted after a visit to see how things were going (Item 16: $\bar{x}$=2.1, 95% CI: 1.8–2.4) - 55% were never/generally not referred to a dietitian, specialist nurse/ health professional (Item 18: $\bar{x}$=2.5, 95% CI: 2.2–2.8) - 42% were never/generally not asked how their visits with other doctors were going (Item 20: $\bar{x}$=3.0, 95% CI: 2.6–3.3) - 24% were never/generally not told how their visits with doctors like heart or vascular specialist helped their treatment (Item 19: $\bar{x}$=3.6, 95% CI: 3.3–3.8)	*****Theme 5. Taking over complex coordination of care*** *describes how difficult it is for patients to obtain a problem/therapy synthesis and to coordinate their own care* - Participants emphasized that living with a rare disease such as SSc requires consultations with many specialized medical providers. Timewise this required coordinating work by themselves. Overall, they perceived these services as highly competent with some variety in professional's ability to summarize results in plain understandable language. This was important for them, to make sense out of the examination results in a specific organ-oriented field. *«I had to take a lung function test every year and the information there was very good. I also thought highly of that doctor. He spent about half an hour with me after the test and explained what it means and what I have to expect, or maybe expect, in the future.» (Patient 2, interview)* - Participants reported that the communication of an overall synthesis (i.e., of the many specialists' examination results and decisions) to gain an overview of individual disease manifestations and outcomes was lacking. They highlighted their need and attempts for a coordinated decision-making, by bringing information from other services into discussions. However, all emphasized that these coordination tasks cannot be conducted equally well by all patients at all time points as it needs expertise, self-empowerment and depends on disease-complexity. *«That's how it is in the hospital, I understand that, they have a lot to do, but then someone comes about blood vessels, then someone about the lungs, and then there's someone about the heart, totally different things. And there is no summery at the end. I am no professional and I can't put the puzzle together from these pieces.» (Patient 2, interview)* - Remarkably, some highly experienced patients reported that they took over the coordination of the involved professionals (e.g., organ specialists, other HPs) and made them aware of their multiple problems to be considered in the overall decision making. This gave them a sense of control. *«It was important to me to realize that the disease affects the whole system, everything, physical, emotional, family, material. And our health system is fragmented and organ-related. There is no Care Management or Case Management, at least not in Switzerland. And I had to learn on my own to do that, to see how I can deal with the specialists. These specialists who pounce on one organ system and know a whole lot about that, but don't see the connection or only want maximum therapy for one part. Who pulls this all together if I don't? After all, we can't change the system so quickly. We can only emancipate ourselves.» (Patient focus group)* - Additionally, some participants highlighted the problem of short-coming economic incentives in our fragmented healthcare system, which prevents care coordination and long-term savings. *«I need 3x 50mg per day. And then I found out that there is also Sildenafil from Sandoz, 3x 50 and I figured out what that costs for a year. The Revatio, 20mg, or Sandoz 50mg. Sandoz 50mg costs almost 10,000 Franken less per year. I blame the whole system a little. There are things that could be optimized using these doses or brands. I would think looking at such things would be part of the medication check the pharmacies make.» (Patient 3, interview)*

	****Theme 6. Relying on an accessible and trustworthy team*** *describes patients' initiatives to find reliable professionals and peers to support them on an ongoing basis*
	- Participants highlighted that the 'rigid' annual monitoring appointments have the advantage that examinations with a range of relevant specialists are bundled and coordinated within one centre of expertise. This enables easy and reliable access to a defined range of providers once a year. However, individual adaptations to this plan (e.g., meetings with additional professionals for specific problems) were only possible to a limited extent. *«I like having an assessment where there is a location once a year. I don't live directly near the hospital and it's really great for me if I don't always have to make the trip. But what isn't so good, you can't always introduce additional things. Even if you said you wanted to when the date was set.» (Patient 1, interview)* - Building their own trustworthy team of professionals was a major point raised by participants to improve care. Having confidence in their expertise and being cared for continuously over a long period of time was crucial for them. They even paid for consultations and therapies not reimbursed by the health insurance out of their own pockets to collaborate with professionals of their preference and receive the therapies they needed. *«With respect to Physio, I organized something special for myself. I think the person is very competent, so the relationship is very good. It is not only Physio, but sometimes a bit psychological as well. We've known each other for quite a while. But that's it, when you know each other for some time –now with that one person it's not the problem, with the other it is the problem: it becomes routine. And then the same thing is done, whether you need it or not.» (Patient 1, interview)* - Participants in a later disease stage described how they had learned to educate professionals who were not yet familiar with the disease and its consequences. In this context, they highlighted the importance of self-management support to reach expertise. Trustworthiness of an individual provider was finally also judged on their ability to collaborate with them. *«I see it as a tipping point, a kind of transition where you are quasi the expert and you get asked and you're "empowered" in the sense: I now look after myself. And if I have to go somewhere else, like to a new dentist or a new gynaecologist, then I tell the doctor that I have this disease and that I have dry mouth, for example. The doctor maybe never heard of systemic sclerosis and I can explain it…» (Patient focus group)*

* Qualitative theme accounting for two PACIC dimensions; ** Qualitative theme accounting for one PACIC dimension

5.6 Discussion

In this investigation of SSc care, we found relatively low PACIC values overall. Patients identified the greatest deficits in the areas of *'goal setting/tailoring'* and *'problem solving/contextual counselling'*. These observations are further supported by the qualitative findings that revealed significant need for SSc self-management support and care coordination, both key elements of CCM.

The low PACIC mean overall score of 3.0/5.0 (95% CI: 2.8–3.2) in our study is comparable to findings in patients with common chronic diseases.[26, 30, 36] However, direct comparison of PACIC scores should be done with caution as slightly different version have been used across studies. A 2018 meta-analysis of 34 studies from 13 countries (>25'000 patients with diabetes)[36] identified a pooled score of 3.0 (95% CI: 2.8–3.2). Interestingly, a survey conducted by EURORDIS (a European alliance of 970 rare disease patient organisations from 74 countries) used the abbreviated 11-item PACIC[56] and found patients report a better chronic care experience ($\bar{x}$=3.4 vs. 2.6) when treated in centres belonging to a European Reference Network (ERN) – highlighting the critical role for access to expert care for rare diseases.

Notably, we did not find an association between PACIC scores and HRQoL. However, mean SScQoL scores were significantly associated with a number of self-reported comorbidities (depression, gastrointestinal problems and osteoarthritis). Such findings are in line with studies of common chronic conditions, in which PACIC scores were marginally correlated with HRQoL (r= 0.15 and 0.23).[26, 28, 57] Our observation is explained by qualitative investigation that revealed a number of factors influencing patient ratings of care (i.e., gratitude, faith, loyalty, luck, equity, engagement with the system).[58] Interestingly, patients with lung problems reported higher PACIC levels than those without pulmonary complications. It is plausible that patients' evaluation of care may depend on their perceived level of influence and engagement with the healthcare system – rather than HRQoL *per se*.

Nevertheless, PACIC dimensions can inform development or improvement of integrated models of SSc care.[27] In the present study, PACIC scores indicate shortcomings in *'goal setting/tailoring'* and *'problem solving/contextual counselling'*. The patient-identified gaps in care pose significant barriers to effective self-management. Indeed, the emergent qualitative themes *'not knowing which strategies are effective or harmful'* and *'feeling left alone with disease and psychosocial consequences'* highlight the quantitative findings. Our observations are similar to studies in common chronic conditions that identified the same PACIC dimensions had the lowest mean values.[26, 28] Similarly, prior qualitative work in SSc, found that patients often lack guidance and effective strategies for independent self-management – particularly in relation to disease and psychosocial consequences.[59-61] Indeed, a systematic review of 26 qualitative studies in SSc identified that patients often feel '*alone and misunderstood*' (i.e., fearful avoidance of fellow patients, invisible suffering) despite having the opportunity to meet other patients in support groups.[61] Comparisons at the item level reveal similarities with European patients with other rare diseases.[56] Swiss SSc patients in the present study were –similar to rare disease patients in Europe– rarely helped to plan ahead for self-management in challenging times ($\bar{x}$=2.5 for both groups) or connected with disease-specific patient support groups ($\bar{x}$=2.3 and 2.1 respectively).[56] Importantly, patients in our study noted limitations of traditional peer support groups. The present findings underscore and expand on previously identified gaps in care for patients with SSc and emphasize the importance of eliciting patient-defined goals/outcomes, developing self-management programmes and re-envisioning traditional on-site peer support groups.[16, 60-63] When implementing integrated care, patients and professionals should agree on a joint treatment plan including individualized goals targeting the primary SSc manifestations and consequences. Importantly, patients

need to understand the essential elements for their individual disease self-management and require tailored education across the specialities involved in care. Therefore, it is important to foster provider skills and implement programs supporting psychological and self-management support to enable patients to self-manage their condition on a day-to-day basis.[56]

Like Desmedt et al.[26] and Stuber et al. [35], we observed the highest PACIC scores in the dimensions *'patient activation'* and '*delivery system design/decision support'*– suggesting that patient with SSc generally feel involved in care decisions. Compared to European rare disease patients, Swiss SSc patients are more likely to '*receive treatment choices to think about'* ($\bar{x}$=3.2 vs. 2.8) and consider their care as 'well organized' ($\bar{x}$=3.9 vs. 3.5).[56] Congruently, interviews revealed that patients who had regular medical follow-up perceived their care as *'super organised'* despite a persistent fear of receiving negative results. However, the qualitative theme *'experiencing organized care with limited participation'* – suggests that patients did not feel involved in medical consultations and that decisions were primarily provider-driven. Moreover, the theme *'dealing with the illness in tailored measure'* describes the importance of protecting patients from feeling overwhelmed in confronting SSc – a finding that adds to prior qualitative SSc research.[61] Our qualitative inquiry reflects the importance of soliciting patient input and involving patients in decision-making as well as arranging care to extend and reinforce office-based consultations. Thus, improving healthcare provider competencies in shared decision-making is a key target for effectively implementing integrated SSc care.[64, 65] Stocker et al.[17] highlighted the need for patient decision aids to foster more patient-focused communication and support high quality decisions that are both informed and aligned with patient needs, values and preferences. Furthermore, our study revealed that patients may feel strained by too much, untimely or frightening information and may therefore refuse certain tests, examinations or interventions. To overcome such barriers, timely access to specialized care (e.g., virtual expert consultations, cross-border healthcare, knowledge assets produced by centres of expertise) warrant consideration.[56]

With regard to the PACIC dimension '*follow-up/coordination',* we identified major gaps in the complex care coordination of SSc (i.e., discontinuity and lack of follow-up). Among Swiss SSc patients in this study, patients were more likely to reported receiving feedback and explanations about specialist visits and examinations compared to European rare disease patients ($\bar{x}$=3.6 vs. 2.5).[56] However, qualitative interviews with experienced patients revealed that patients often assume responsibility for complex care coordination themselves. The theme '*taking over complex coordination of care'* underscored the difficulty patients experience coordinating their own care. Similar to European rare disease patients, Swiss SSc patients rarely had contact with their healthcare provider after a visit, potentially explained by suboptimal provider reimbursement for outpatient services in the Swiss health system.[66] Moreover, patients may be receiving care in centres/practices that lack expertise in this rare disease.[56] Importantly, rare disease patients who were treated in centres belonging to a European Reference Network (ERN) reported higher satisfaction with regard to 'being contacted after a visit' ($\bar{x}$=2.8 vs. 2.1). Congruently, our interview participants described '*relying on an accessible and trustworthy team'* as a central theme relating to finding trusted, reliable professionals and peers for ongoing care and support. Several studies have revealed similar gaps in SSc care delivery (i.e., lack of structured multidisciplinary collaboration, inadequately organized follow-up, poor patient-provider relationships.[17, 60, 67-69] Despite the positive impact the chronic care model has demonstrated on disease outcomes, rare disease care models rarely test multi-component interventions (e.g., patient education, patient-held medical records, specialist nurse-led care) in providing coordinated, ongoing, complex care[32, 70] and infrequently incorporate community-based

resources.[71, 72] In diabetes and cancer, chronic care implementation has long utilized specialized nurses and peers for support, case-management and counselling to improve patient-centredness, satisfaction with care and clinical outcomes.[73-76] Additionally, capacity building within health systems may be needed for a more flexible approach to planning consultations (e.g., self-referrals for lab tests and consultations) as well as co-management by patients and professionals (e.g., personal health records) to improve patient access, promote empowerment and reduce travel requirements.[15, 77, 78]

In summary, comprehensive SSc care demands a systematic approach that addresses physical and mental health concerns as well as social consequences/inequities throughout the disease course. A collaborative approach between patients and providers is paramount with shared responsibility for decision-making and goal setting to arrive at a joint treatment plan. Additionally, tailored therapeutic education is an essential component of comprehensive, holistic SSc care. In regard to care delivery and follow-up/coordination important targets include improving provider skills (e.g., decision-making, self-management support) and novel modes of care (e.g., decision aids, virtual consultations, specialized nurses, peer-to-peer support, self-referrals, personal health records) may help create a more person-centered approach to SSc care.

Relative strengths of this study include the comprehensive assessment of patient experiences and needs for SSc chronic illness care using both quantitative and qualitative data from patients spanning a range of disease experience (i.e., newly diagnosed until long diseases duration). The study also has a number of limitations. First, the sample size is relatively limited, yet 101 patients included in the quantitative survey is a sizeable cohort for a rare disease.[79] Similarly, the qualitative sample used to contextualise the PACIC data was rather small. In addition, the PACIC has not been formally validated for SSc. The PACIC has been used in rare disease populations[56] –yet it is unclear how well this generic instrument assesses the challenges specific to rare disease care (e.g. lack of treatment options and specialized healthcare professionals) and disease-specific patient needs. Prior research in common chronic diseases suggest that the single PACIC score is an appropriate measure of global chronic care – yet it is difficult to distinguish between the five PACIC dimensions.[42, 80] Unlike previous validation studies using confirmatory factor analysis, we applied Mokken Scale Analysis that relates to nonparametric Item Response Theory (IRT) models and is more appropriate for non-normally distributed data.[49, 81] Our validation revealed five items of the PACIC-20 dimensions not fitting our data. After excluding these problematic items, H coefficients were found to be strong for the global (0.52) and subscales (0.69, 0.70) suggesting a robust unidimensional scale (**Supplementary material 2**). However, from a clinical perspective, excluding these items may be controversial - as considering scalability coefficients alone may yield an incomplete picture.[49] Indeed, patient care experiences with regard to peer support (e.g., item 10), follow-up (e.g., item 17) and referral to HPs (e.g., item 18) would be important for quality assessment of SSc and rare disease care in general.

5.7 Conclusions

In summary, re-envisioning current SSc care practices and incorporating components of the Chronic Care Model (CCM) offer opportunities to improve chronic disease management of SSc patients in Switzerland. Our findings suggest that shared decision-making, goal-setting and tailored counselling are needed to better support patients to develop self-management skills. New models of care must focus on coordinating the complex care (including ongoing follow-up), and facilitating patients and professionals in sharing a leadership role to improve patient-centredness, satisfaction with care and clinical outcomes.

Establishing more flexible approaches to scheduling consultations and fostering co-management by patients and professionals merits attention (e.g., specialized nurse-led case management and peer-to-peer counselling). Future research would be needed to receive a valid and reliable measure for the assessment of chronic illness care in rare diseases as SSc. Additional investigation may focus on comparing and contrasting centres providing care for people living with SSc and other rare (rheumatic) diseases to discern the key elements of chronic illness management for these populations.

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5.9 Supplementary material

Supplementary material 1

Mokken scale analysis of the original 20-item Patient Assessment of Chronic Illness Care (PACIC)

Supp. 1a. Mokken scale analysis of global scale

	Items	Scalability (*H*)	Standard error
Global scale		**0.461**	**0.040**
	Item 1	0.463	0.057
	Item 2	0.420	0.058
	Item 3	0.460	0.052
	Item 4	0.493	0.053
	Item 5	0.490	0.065
	Item 6	0.546	0.046
	Item 7	0.552	0.046
	Item 8	0.559	0.044
	Item 9	0.490	0.063
	Item 10	0.339	0.069
	Item 11	0.391	0.064
	Item 12	0.535	0.046
	Item 13	0.581	0.039
	Item 14	0.511	0.053
	Item 15	0.472	0.064
	Item 16	0.392	0.077
	Item 17	0.335	0.080
	Item 18	0.371	0.065
	Item 19	0.340	0.073
	Item 20	0.449	0.056

Supp. 1b. Mokken scale analysis of subscales

	Items	Scalability (*H*)	Standard error
Patient activation		**0.664**	**0.059**
	Item 1	0.720	0.050
	Item 2	0.677	0.060
	Item 3	0.595	0.075
Delivery System Design/ Decision Support		**0.598**	**0.065**
	Item 4	0.593	0.073
	Item 5	0.605	0.073
	Item 6	0.596	0.068
Goal setting/ Tailoring		**0.502**	**0.061**
	Item 7	0.545	0.064
	Item 8	0.596	0.054
	Item 9	0.524	0.071
	Item 10	0.418	0.078
	Item 11	0.423	0.079

Problem solving/ Contextual counselling		**0.673**	**0.054**
	Item 12	0.682	0.052
	Item 13	0.697	0.053
	Item 14	0.698	0.056
	Item 15	0.616	0.075
Follow-up/ Coordination		**0.418**	**0.053**
	Item 16	0.368	0.073
	Item 17	0.312	0.081
	Item 18	0.383	0.067
	Item 19	0.552	0.052
	Item 20	0.462	0.059

Table legend: scalability $H \geq 0.50$ = strong, 0.49 to 0.40 = moderate, 0.39 to 0.30 = weak, while values of < 0.30 are not considered as unidimensional.

Supplementary material 2

Mokken scale analysis of the adapted 15-item Patient Assessment of Chronic Illness Care (PACIC)

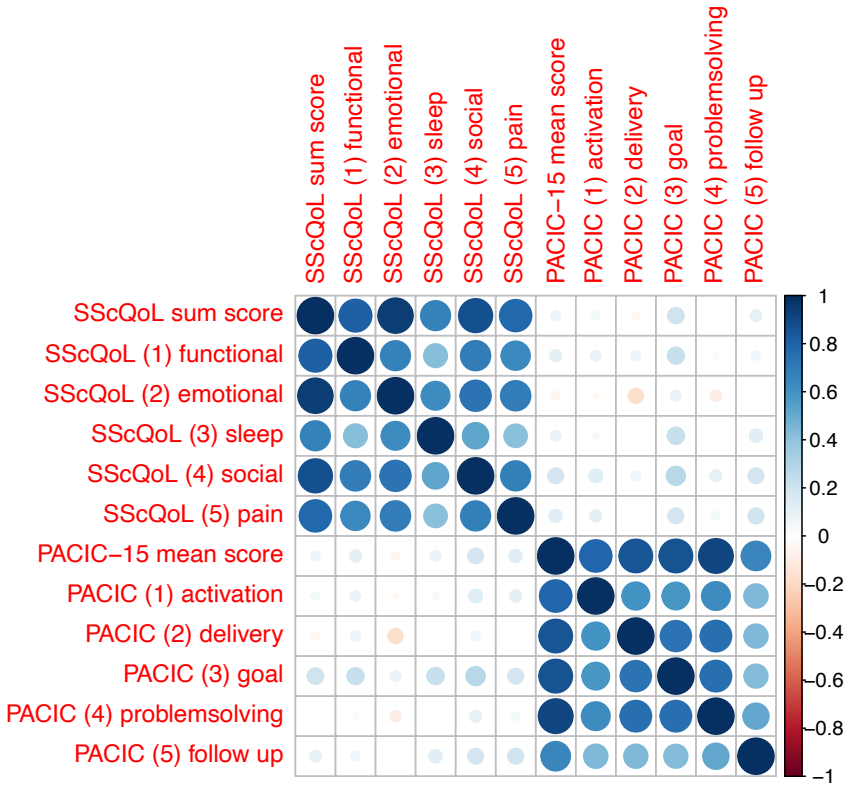
Table 2a. Mokken scale analysis of global scale			
	Items	**Scalability (*H*)**	**Standard error**
Global scale		**0.521**	**0.042**
	Item 1	0.497	0.058
	Item 2	0.460	0.059
	Item 3	0.511	0.054
	Item 4	0.506	0.058
	Item 5	0.545	0.065
	Item 6	0.564	0.051
	Item 7	0.591	0.047
	Item 8	0.584	0.046
	Item 9	0.520	0.065
	Item 12	0.566	0.048
	Item 13	0.621	0.040
	Item 14	0.559	0.054
	Item 15	0.494	0.068
	Item 19	0.323	0.081
	Item 20	0.475	0.061
Table 2b. Mokken scale analysis of subscales			
	Items	**Scalability (*H*)**	**Standard error**
Patient activation		**0.664**	**0.059**
	Item 1	0.720	0.050
	Item 2	0.677	0.060
	Item 3	0.595	0.075
Delivery System Design/ Decision Support		**0.598**	**0.065**
	Item 4	0.593	0.073

	Item 5	0.605	0.073
	Item 6	0.596	0.068
Goal setting		**0.687**	**0.057**
	Item 7	0.720	0.065
	Item 8	0.736	0.050
	Item 9	0.599	0.077
Problem solving		**0.673**	**0.054**
	Item 12	0.682	0.052
	Item 13	0.697	0.053
	Item 14	0.698	0.056
	Item 15	0.616	0.075
Follow-up/ Coordination		**0.704**	**0.061**
	Item 19	0.704	0.061
	Item 20	0.704	0.061

Table legend: scalability $H \geq 0.50$ = strong, 0.49 to 0.40 = moderate, 0.39 to 0.30 = weak, while values of < 0.30 are not considered as unidimensional.

Supplementary material 3

Correlations (pearson's *r)* between the mean PACIC-15 and SScQoL scores



Chapter 6 Patient and healthcare professional eHealth literacy and needs for systemic sclerosis support – a mixed methods study

Agnes Kocher [1,2]; Michael Simon [1,3]; Andrew A. Dwyer [4,5]; Catherine Blatter [1]; Jasmina Bogdanovic [1]; Patrizia Künzler-Heule [1,6]; Peter M. Villiger [7], Diana Dan [8]; Oliver Distler [9]; Ulrich A. Walker [10]; Dunja Nicca [1,11]

[1] Institute of Nursing Science (INS), Department Public Health (DPH), Faculty of Medicine, University of Basel, Switzerland

[2] Head office of Nursing, Inselspital, Bern University Hospital, University of Bern, Switzerland

[3] Nursing and Midwifery Research Unit, Inselspital, Bern University Hospital, University of Bern, Switzerland

[4] Boston College, Connell School of Nursing, Chestnut Hill, Massachusetts, USA

[5] Massachusetts General Hospital Munn Center for Nursing Research, Boston, Massachusetts, USA

[6] Department of Gastroenterology/Hepatology and Department of Nursing, Cantonal Hospital St. Gallen, Switzerland

[7] Medical Center Monbijou, CH-3011 Bern, Switzerland

[8] Service of Rheumatology, Lausanne University Hospital, University of Lausanne, Lausanne, Switzerland

[9] Department of Rheumatology, University Hospital Zurich, Zurich, University of Zurich, Switzerland

[10] Department of Rheumatology, University Hospital Basel, Basel, Switzerland

[11] Department of Global and Public Health, Institute for Epidemiology, Biostatistics and Prevention, University of Zurich, Switzerland

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6.1 Abstract

Objectives

We engaged systemic sclerosis (SSc) patients and healthcare professionals to assess electronic health (eHealth) literacy and needs relating to web-based support using internet-based information and communication technologies (ICT).

Methods

We employed an explanatory sequential mixed methods design. First, we conducted a cross-sectional survey in patients (n=101) and professionals (n=47). Next, we conducted three focus groups with patients, family members and professionals (n=17).

Results

Of patients, 89.1% used ICT at least weekly for private communication. Patients reported relatively high comprehension of eHealth information ($\bar{x}$=6.7, 95% CI 6.2–7.3, Range 1-10), yet were less confident

evaluating information reliability ($\bar{x}$=5.8, 95% CI 5.1–6.4) and finding eHealth apps ($\bar{x}$=4.8, 95% CI 4.2–5.4). Patients and professionals reported little experience with web-based self-management support.

Focus groups revealed "*considering non-ICT-accessible groups"* and *"fitting patients' and professionals' technology"* as crucial for acceptability. In relation to understanding/appraising eHealth, participants highlighted that general SSc-information is not tailored to individuals' disease course. Recommendations included "*providing timely, understandable, and safe information"* and *"empowering end-users in ICT and health decision-making skills"*. Professionals expressed concerns about lacking resources. Patients were concerned about data security and person-centredness. Key eHealth drivers included *"addressing end-user perceptions"* and *"putting people at the centre of technology"*.

Conclusions

Patients and professionals need education/training to support uptake of eHealth resources. Key elements include guiding patients to timely/reliable information and using eHealth to optimize patient-provider communication. Design that is responsive to end-users needs and considers individuals with limited eHealth literacy and/or ICT access appears to be critical for acceptability.

KEYWORDS

Systemic sclerosis; Health services research; Outcome and Process Assessment, Health Care; Nursing

6.2 Key messages

What is already known about this subject?

- Internet-based information and communication technologies (ICT) have become increasingly important for chronic disease management and hold promise for rare disease patients who are geographically dispersed.
- In systemic sclerosis (SSc), little is known about electronic health (eHealth) literacy or how patients and providers use eHealth to inform clinical practice and make health decisions.

What does this study add?

- Quantitative findings reveal patients have difficulty appraising the quality of eHealth information and both patients and professionals rarely use online information for health and care decisions.
- Qualitative findings indicate patients and professionals lack experience with eHealth support (e.g., apps, online forums, self-help groups) and desire support/guidance in appraising eHealth resources.

How might this impact on clinical practice or future developments?

- Involving stakeholders early in the eHealth development process is important for user-centred design, supporting equity and producing high-quality eHealth resources that are responsive to patient/provider needs and complementary to face-to-face care/support.

6.3 Background

Internet-based information and communication technologies (ICT) have become increasingly recognized in healthcare as a means to improve health – termed eHealth.[1] In the light of this trend, the Chronic Care Model (a reference model for chronic care improvement) was amended in 2015 to include

ICT approaches.[2] Broadly, the updated model aims to improve health outcomes through empowering patients and healthcare professionals by introducing web-based solutions to support self-management, delivery-system design, clinical decision support, clinical information systems and eHealth education. Notably, eHealth literacy is a fundamental prerequisite for empowerment within such care models.

eHealth literacy is defined as people's knowledge, motivation and competence to "access", "understand", "appraise" and "apply" health information from electronic sources to address or solve a health problem:[3, 4] "Access" refers to the ability to seek, find and obtain health information, "understand" refers to the ability to comprehend information, "appraise" to interpret and evaluate information and "apply" describes the ability to use health information to make informed decisions. Greater eHealth literacy is associated with better access to health care, more pro-active health/self-management behaviours, and improved health-related outcomes.[5] Similarly, provider eHealth education and attitudes toward ICT use have considerable impact on eHealth implementation.[6] Therefore, it is crucial to assess eHealth literacy of patients and professionals eHealth literacy and their respective needs to ensure uptake and sustainability of eHealth services.

Prior research on rare multisystemic, autoimmune connective-tissue disease such as systemic sclerosis (SSc) and systemic lupus erythematosus (SLE) has primarily focused on patient general health literacy and barriers to ICT use.[7, 8] There is a paucity of evidence on eHealth literacy among rheumatologic providers. In regard to SSc/SLE eHealth support, web-based resources are often of low quality, have inadequate readability, and limited functionality.[9-11] Several studies demonstrate that patients with rare connective-tissue diseases and their providers are interested in web-based education and support.[12-14] However, few online programs focus on critical concepts of health equity, patient engagement and empowerment. The Lupus Interactive Navigator is a web-based self-management program for SLE with high patient ratings of content, usability and acceptability.[15] In SSc, several studies have shown that appropriate eHealth-interventions can support high-quality care through reliable disease information, self-management support, and disease monitoring.[16-19] Despite such promising results, little is known about SSc patient and health professional eHealth literacy or how eHealth is applied to inform clinical practice and daily life decisions. In particular, patients affected by rare diseases such as SSc, often have limited access to health information and care. Thus, it is important to explore how web-based technologies can best facilitate access to high-quality, coordinated SSc care. Similarly, understanding stakeholder eHealth literacy, needs and perspectives is important for developing targeted, user-centred interventions that are accepted.[20]

The MANagement Of Systemic Sclerosis (*MANOSS*) project aims to fill existing gaps in SSc care by developing an eHealth-enhanced rare disease chronic care model for SSc patients in Switzerland.[21] Part of the *MANOSS* project involves conducting a contextual analysis with stakeholder involvement to inform user-centred design.

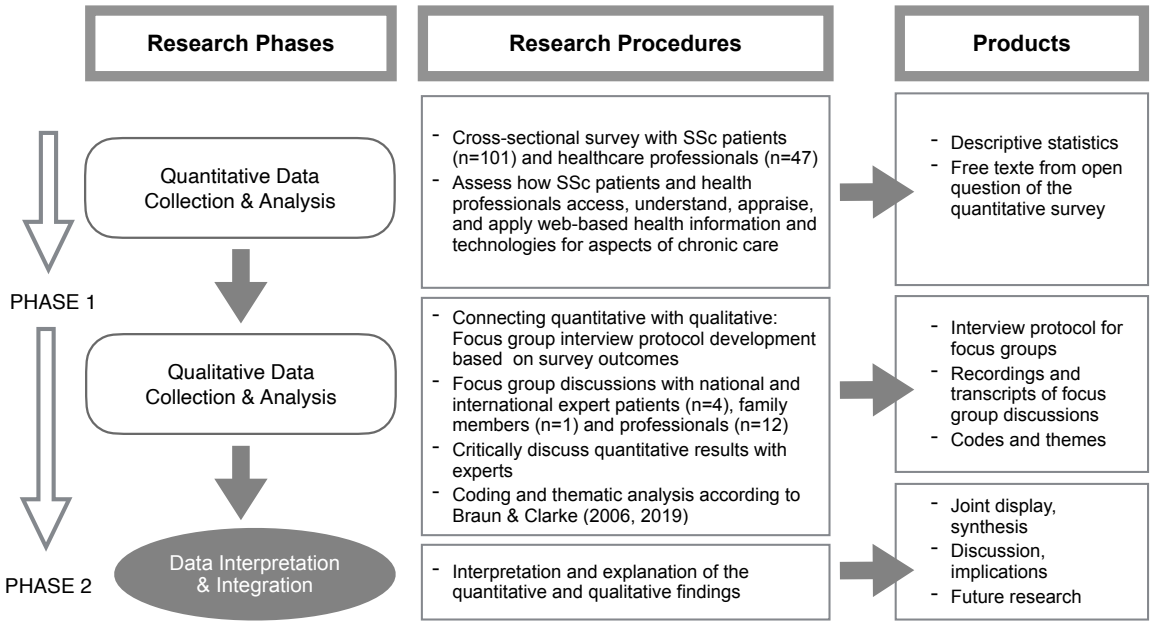
This explanatory mixed methods study aimed to describe eHealth literacy of patients and healthcare professionals as well as perspectives and needs for web-based chronic care support. The quantitative phase assessed how SSc patients and professionals access, understand, appraise, and apply web-based health information and technologies for aspects of chronic care. The quantitative results informed the subsequent qualitative phase which aimed to deepen our understanding of how eHealth literacy, perspectives and needs explain eHealth use and can be incorporated into user-centred eHealth solutions within a new model of care.

6.4 Methods

6.4.1 Study design

We employed an explanatory sequential mixed methods design[22] involving multiple centres providing SSc care (**Figure 1**). The first phase utilized quantitative data from a cross-sectional survey of Swiss SSc patients and healthcare professionals. Analyses informed the qualitative inquiry consisting of three focus groups with Swiss/international patients and professionals. The qualitative findings were used to explain quantitative findings. The overall *MANOSS* project[21] was reviewed and approved by the responsible Swiss ethics committee (EKNZ 2018-01206) and conducted in accordance with the principles of the Helsinki doctrine.

Figure 1. Study diagram for the explanatory, sequential mixed methods design



6.4.2 Patient and public involvement

Involvement of patient research partners and relevant stakeholders is strongly recommended for developing web-based technologies.[23, 24] Key stakeholders in this study were the Swiss League against Rheumatism, a patient research partner and the Swiss Scleroderma Association. Additionally, the European alliance of associations for rheumatology (EULAR) study group, dedicated to improving and standardizing non-pharmacological management of connective tissue diseases (CTDs), supported recruitment of participants for the qualitative inquiry.

6.4.3 Quantitative data collection

Sample and setting

We targeted a convenience sample of 100 adult patients (>18 years) spanning a range of SSc disease severity/experiences and 50 healthcare professionals with varied levels of experience in treating SSc. We recruited German- and French-speaking participants (patients and professionals) from all Swiss University hospitals (Basel, Bern, Geneva, Lausanne, Zurich), one regional (state) hospital (Lucerne), rheumatology outpatient clinics, and the Swiss scleroderma patients' association (www.sclerodermie.ch) according to the *MANOSS* study protocol.[21]

Variables and measurement

Validated patient-reported outcome measures (PROMs) for rare diseases such as SSc are scarce. Moreover, given the rate of technologic advances, available eHealth literacy measures do not adequately cover current technological developments.[25-27] Hence, we constructed a set of pragmatic items tailored to SSc, including dimensions of instruments developed by Halwas et al.[28] and Vanhoof et al.[29] Item selection was guided by the dimensions of eHealth literacy including "access", "understand and appraise" and "apply" ICT/eHealth services (**Table 1**). Participants were invited to provide open-ended, free text comments at the end of the questionnaire. Participants were given the option to complete the questionnaire online or in paper-pencil format (professionals online only).

Table 1. Quantitative variables and measurements

Dimension	Questionnaire	Variables and measurement		Response options
		Patient questionnaire	***Provider questionnaire***	
Access *ICT possession*	Possession and use of modern information and communication technologies (Vanhoof et al., 2018)	Possession of cell phone; smartphone; desktop, laptop, or tablet computer; fitness tracker or smartwatch. Internet access; subscription for smartphone; subscription at home. Download speed: > 50.0 Mbit per second; 20.0-50.0 Mbit; <20.0 Mbit	Possession of cell phone; smartphone; desktop, laptop, or tablet computer; fitness tracker or smartwatch.	Patients: yes / no / don't know Providers: employer's device / own device /no device
Understand & appraise *Confidence using ICT*		I feel confident using my smartphone, tablet, laptop and/or desktop computer. I feel confident using the internet; the internet makes my everyday life easier		not at all / not true / neither / applies / fully applies
Confidence using eHealth	eHealth literacy (Halwas et al., 2017)	I understood health information on the internet, which I have already used well; eHealth offers (online health offers) have raised my medical knowledge; I know where I can find suitable eHealth offers for my health issues; I know how to find suitable applications (apps) for my health care; I know how to use health apps; the offers on the internet are useful for making decisions about my health; Feeling safe making decisions based on online information and/or offers; I can differentiate reliable from unreliable online information and/or offers	Online offers (e.g., training programs) have raised my medical knowledge; I know how to find suitable apps for the healthcare of my patients; The offers on the internet are useful for making decisions about the health of my patients; Feeling safe making decisions based on online information; I can differentiate reliable from unreliable online information and/or offers	10-point Likert scale: "I totally disagree" to "I totally agree"
Apply *General ICT usage*	Possession and use of modern information and communication technologies (Vanhoof et al., 2018)	Frequency of internet-use: to send and/or receive emails; to read news (e.g., online magazine or newspaper); for social networking (e.g., Facebook); to communicate (e.g., chat, Skype, Facetime, WhatsApp); to download mobile apps; use mobile apps on the smartphone (e.g., train timetable, weather); watch films; use a fitness tracker (e.g., record pulse, speed, distance) or a smartwatch	Frequency of internet-use to: send and/or receive emails	never / several times a year / several times a month / several times a week / daily

eHealth usage	eHealth usage questionnaire (Halwas et al., 2017)	Do you use apps which support you in a healthy lifestyle? If yes, which ones? (open text) Which of the devices do you prefer to use to search for information on the internet? (Smartphone, tablet, portable or desktop computer)	Do you use apps in your private life which support you in a healthy lifestyle? Do you recommend apps to your patients that support them in a healthy lifestyle?	yes, no
		Frequency of internet-use to: contact a physician or another health professional via email; search for health information (e.g., on illness, symptoms, therapies); search for a medical specialist; download and store health information (e.g., brochures, pictures, videos); read a health issue related blog; discuss with other patients in an online forum; participate in a self-help group; remind you of a doctor's appointment (e.g., SMS or email); other health-related purposes (e.g., online database)	Frequency of internet-use to: contact patients via email; search for information (e.g. on diseases, therapies); communicate with patients (e.g., SMS, Skype, Facetime, WhatsApp); discuss with patients in an online forum; make appointments with patients; remind patients of an appointment (e.g., SMS or e-mail)	never / several times a year / several times a month / several times a week / daily

6.4.4 Quantitative data analysis

We performed descriptive statistics (frequencies/percentages or means/medians with 95% confidence intervals and interquartile ranges) to summarize quantitative survey data and socio-demographic characteristics (R, Version 4.0.4). To compare groups (i.e., sex, age groups, education, patient–professionals), we computed standardized mean differences (SMD) which are identical to Cohen's d, using the tableone-package for R. Compared to p values, SMD is more appropriate for calculating effect size estimates in small, uneven datasets – such as the ones analysed in this study.[30] A SMD ≥ 0.2, ≥ 0.5 and ≥ 0.8 depict small, medium and large differences between groups respectively. We calculated 95% confidence intervals (CIs) for means to facilitate visual comparison between ratings. Differences between groups were defined as means with distinct, non-overlapping CIs.

6.4.5 Qualitative data collection

Sample and setting

We used a purposeful sampling strategy to recruit 12-18 participants with expertise in SSc care/management. We defined participants with expertise as individuals with several years of experience with (1) SSc as a patient or (2) family member and/or (3) professional experience in chronic care, implementation science, and/or health policy. Purposeful sampling focused on individuals with varied expertise in national or international care settings, across disciplines (e.g., physicians, nurses, physiotherapists, occupational therapists and patient experts). Swiss professionals were recruited from Swiss University Hospitals (Bern, Lausanne, Zurich) and the Swiss League against Rheumatism (Rheumaliga Schweiz). International participants were recruited via the EULAR non-pharmacological management of connective tissue diseases (CTDs) study group.

Focus group discussions

The quantitative study results informed questions for focus group discussions. Due to the COVID-19 pandemic, focus groups were conducted using an online video conferencing system. With participant consent, focus group discussions were recorded. Briefly, findings of our systematic literature review and the quantitative study findings were provided to orient participants. Findings were discussed using open-ended prompts to elaborate quantitative results (i.e., What is important/surprising? What fits your experiences? What is contradicting to your clinical experiences? What are important aspects that should be taken into account when improving chronic care for SSc patients?). Subsequently, primary care needs and problem areas for care were discussed for national (focus groups 1 and 2) and international contexts (focus group 3).

6.4.6 Qualitative data analysis

Focus group transcriptions and free text comments from the quantitative survey were analysed using reflexive thematic analysis.[31, 32] In brief, analysis was a recursive process that started with familiarisation with the data and coding of the text. Subsequently, codes were collated to build initial inductive themes (i.e., patterns of shared meaning across all participants) and mapped to the corresponding eHealth literacy dimension. Finally, themes were refined and named based on original data (i.e., quotes, codes).

6.4.7 Mixed methods data integration

As noted, quantitative data informed the structure of the qualitative study. Subsequently, the qualitative data were used to explain the quantitative findings. Importantly, the mixed methods approach provides deeper insight for model development than either method in isolation.[22] We present our quantitative

results first, followed by a joint display including key quantitative findings and qualitative in-depth themes for each eHealth literacy dimension. The resulting synthesis of quantitative and qualitative findings identified key targets for further model development and user-centred design.

6.5 Results

6.5.1 Participants' characteristics

The quantitative survey was completed by 101 patients and 47 professionals (**Table 2**). In total, 17 individuals (n=12 professionals; n=4 SSc patients; n=1 family member) participated in focus group discussions. All four patient participants were active members of a patient organization and three had a medical and/or scientific background.

Table 2. Participant characteristics (quantitative survey and qualitative focus groups)

Patients		**Quantitative (n=101)**	**Qualitative (n=4)**
Sex [n (%)]	Female	77 (76.2%)	4 (100%)
	Not reported	4 (4%)	-
Age (years) [median (IQR)]		60 (50-68)	-
Country of healthcare provision [n (%)]	Switzerland	101 (100%)	3 (75%)
	United Kingdom		1 (25%)
Disease subset, self-reported [n (%)]	lcSSc	31 (30.7%)	2 (50%)
	dcSSc	36 (35.6%)	2 (50%)
	Other rare rheumatic disease	3 (3.0%)	-
	Don't' know	25 (24.8%)	-
Disease duration (years) [median (IQR)]		8 (5-15)	32 (17-40)
Questionnaire [n (%)]	Online survey	43 (42.6%)	-
	Paper survey	58 (57.4%)	-
Country of origin [n (%)]	Switzerland (German region)	79 (78.2%)	2 (50%)
	Switzerland (French region)	22 (21.8%)	-
	Germany	-	1 (25%)
	United Kingdom	-	1 (25%)
Marital status [n (%)]	Single	13 (12.9%)	-
	Married/cohabiting	68 (67.3%)	-
	Divorced, separated or widowed	16 (15.9%)	-
	Not reported	4 (4%)	-
Highest educational degree [n (%)]	Tertiary level	37 (36.7%)	-
	Upper secondary	48 (47.5%)	-
	Compulsory	13 (12.9%)	-
	No completed education	1 (1%)	-
	Not reported	2 (2%)	-
Employment [n (%)]	Employed	50 (49.5%)	-
	Full time (80-100%)	22 (21.8%)	-
	Part time (< 80%)	28 (27.9%)	-
Reasons for non-employment [n (%)]	Retired	30 (29.7%)	-
	On disability or sick leave	10 (9.9%)	-
	In training/student	7 (7%)	-
	Looking for work	4 (4%)	-
Family members			**Qualitative (n=1)**
Sex [n (%)]	Female	-	1 (100%)

Country of healthcare provision [n (%)]	Germany	-	1 (100%)
Healthcare professionals		**Quantitative (n=47)**	**Qualitative (n=12)**
Sex [n (%)]	Female	40 (85.1%)	10 (83.3%)
Age (years) [median (IQR)]		41 (31-51)	-
Country of workplace [n (%)]	Switzerland	47 (100%)	6 (50%)
	Austria		2 (16.7%)
	Belgium		1 (8.3%)
	Sweden		1 (8.3%)
	United States of America		2 (16.7%)
Working experience (years) [median (IQR)]		13 (7-23)	-
Rheumatology experience (years) [median (IQR)]		6 (3-12)	-
Number of SSc patients per year (patients) [median (IQR)]		15 (5-29)	-
Position [n (%)]	Registered Nurse	13 (27.2%)	
	Physiotherapist	10 (21.3%)	2 (16.7%)
	Rheumatologist	9 (19.2%)	2 (16.7%)
	Occupational Therapist	9 (19.2%)	4 (33.3%)
	Advanced Practice Nurse	2 (4.3%)	3 (25%)
	General practitioner	1 (2.2%)	-
	Psychologist	1 (2.2%)	-
	Social worker	1 (2.2%)	-
	Health policy	-	1 (8.3%)
	Not reported	1 (2.2%)	-
Working setting [n (%)]	University hospital	36 (76.6%)	-
	Non-university hospital	7 (14.8%)	-
	Private outpatient clinic	2 (4.3%)	-
	Rehabilitation clinic	2 (4.3%)	-

Note: lcSSc = limited cutaneous systemic sclerosis, dcSSc = diffuse cutaneous systemic sclerosis

6.5.2 Quantitative survey

The quantitative results are reported according to the described eHealth literacy dimensions (i.e., "access", "understand/appraise", "apply").

Access

Survey results indicate both patients and professionals have adequate access to ICT (**Table 3**). The overwhelming majority of patients (91/101, 90.1%) had access to the internet. Professionals were commonly equipped with devices – yet smartphones, tablets and smartwatches were seldom used for clinical purposes.

Table 3. Patient and healthcare professional access to ICT

ICT technology	**Patients (n=101)**	**Professionals (n=47)**	
	own ICT	ICT for patient communication	
		equipment of employer	*own device*
Cell phone	24 (23.8%)	25 (53.2%)	2 (4.3%)
Smartphone	81 (80.2%)	2 (4.3%)	13 (27.7%)
Tablet	49 (48.5%)	9 (19.2%)	3 (6.4%)
Portable computer (Laptop)	63 (62.4%)	38 (80.9%)	4 (8.5%)
Desktop computer	46 (45.5%)	40 (85.1%)	1 (2.1%)
SmartWatch	7 (6.9%)	0 (0.0%)	0 (0.0%)
Internet access	91 (90.1%)		
Home-based internet, download speed:			
> 50.0 Mbit/sec	20 (19.8%)		
20.0 - 50.0 Mbit/sec	26 (25.7%)		
< 20.0 Mbit/sec	8 (7.9%)	n/a	n/a
download speed unknown	29 (28.7%)		
no contract	12 (11.9%)		
not reported	6 (6.0%)		
Mobile internet, download data volume:			
limited data volume	34 (33.7%)		
unlimited data volume	34 (33.7%)		
data volume unknown	6 (5.9%)	n/a	n/a
no contract	21 (20.8%)		
not reported	6 (5.9%)		

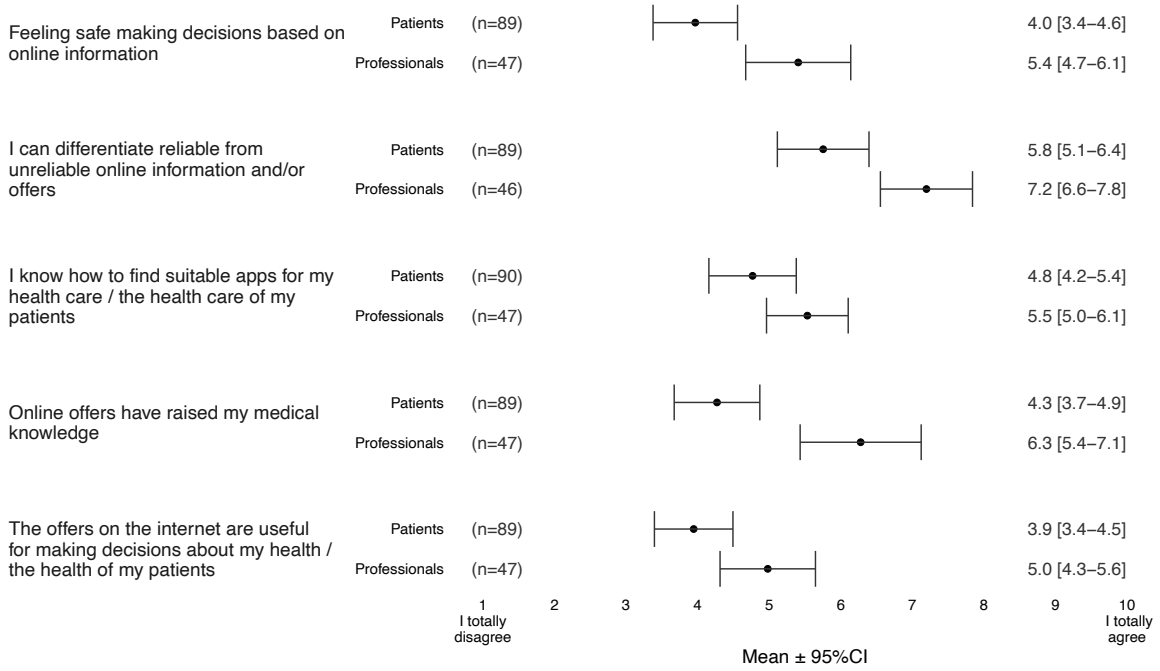
Understand and appraise

The majority of patients felt confident using a smartphone/tablet (70/101, 69.3%) and/or portable/desktop computer (71/101, 70.3%). Patients indicated few problems comprehending health-related information on the internet ($\bar{x}$=6.7, 95% CI: 6.2–7.3, range: 1–10). No notable differences were found in relation to sex or age. However, patients with less education (i.e., compulsory education only) reported poorer understanding ($\bar{x}$=4.5 vs. 7.1; SMD = 0.81). Patients reported relatively limited ability to appraise eHealth information related to their health issues ($\bar{x}$=5.8, 95% CI: 5.1–6.4), find health apps ($\bar{x}$=4.8, 95% CI: 4.2–5.4) and other eHealth offerings ($\bar{x}$=5.5, 95% CI: 4.9–6.2). Patients did not perceive that online resources increased their medical knowledge ($\bar{x}$=4.3, 95% CI: 3.7–4.9) or helped them making informed health decisions ($\bar{x}$=3.9, 95% CI: 3.4–4.5). Younger patients (<45 years) trended towards

greater understanding of eHealth information ($\bar{x}$=7.8 vs. 6.6; SMD = 0.48) and more confident decision-making based on online information ($\bar{x}$=5.1 vs. 3.8; SMD = 0.43).

Compared to patients, healthcare professionals (**Figure 2**) reported greater ability to assess reliability of online information ($\bar{x}$=7.2 vs. 5.8; SMD = 0.55) and that eHealth resources increased their medical knowledge ($\bar{x}$=6.3 vs. 4.3; SMD = 0.70). Similar to patients, professionals reported limited benefit of online information for health decision-making ($\bar{x}$=5.0, 95% CI: 4.3–5.6) and lacking knowledge in finding health apps ($\bar{x}$=5.5, 95% CI: 5.0–6.1).

Figure 2. Patient and healthcare professional perceived understanding and appraising of eHealth (mean and 95% CI)



Apply

Notably, most patients (90/101, 89.1%) used the internet weekly – primarily for personal, private purposes (e.g., communication, mobile applications, online news) (**Figure 3)** but not for health purposes (**Figure 4 and 5**). Similarly, almost all healthcare professionals had used the internet at least weekly for email communication (45/47, 95.7%), nevertheless only 19/47 (40.4%) used email weekly for patient communication. Both patients and professionals indicated relatively limited experience with web-based self-management support. Most patients had never used an online support group (70/92, 76.1%) or forum (75/90, 83.3%), while 45/46 (97.8%) of healthcare professionals had never participated in an online patient forum. Only 14/101 (13.9%) patients had used apps to improve their health compared to 20/47 (42.5%) professionals. In total, only 14/47 (29.8%) healthcare professionals had recommended eHealth apps to their patients.

Figure 3. Internet use of patients for private purposes

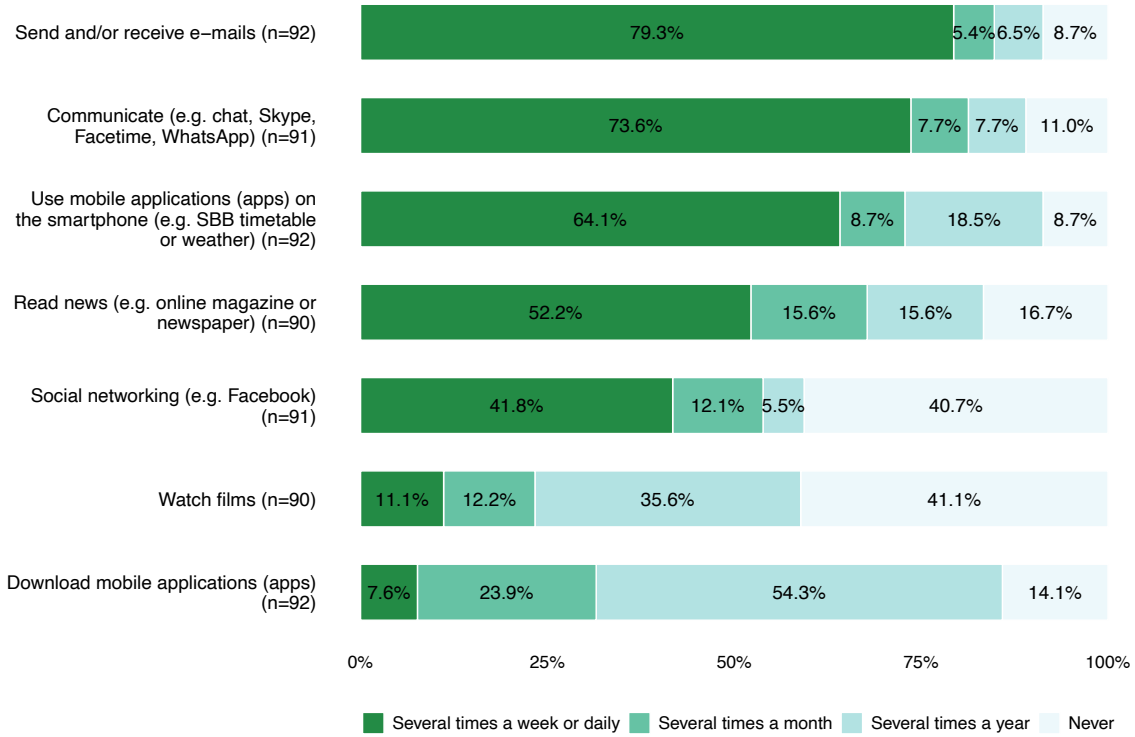


Figure 4. Internet use of patients and professionals for health care

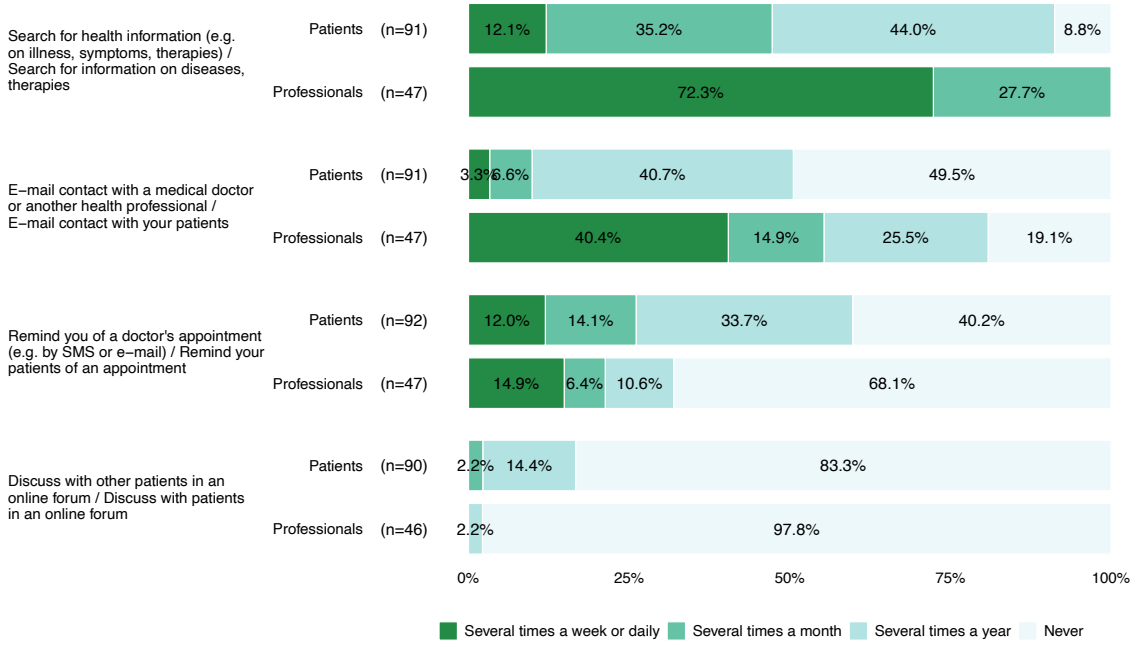
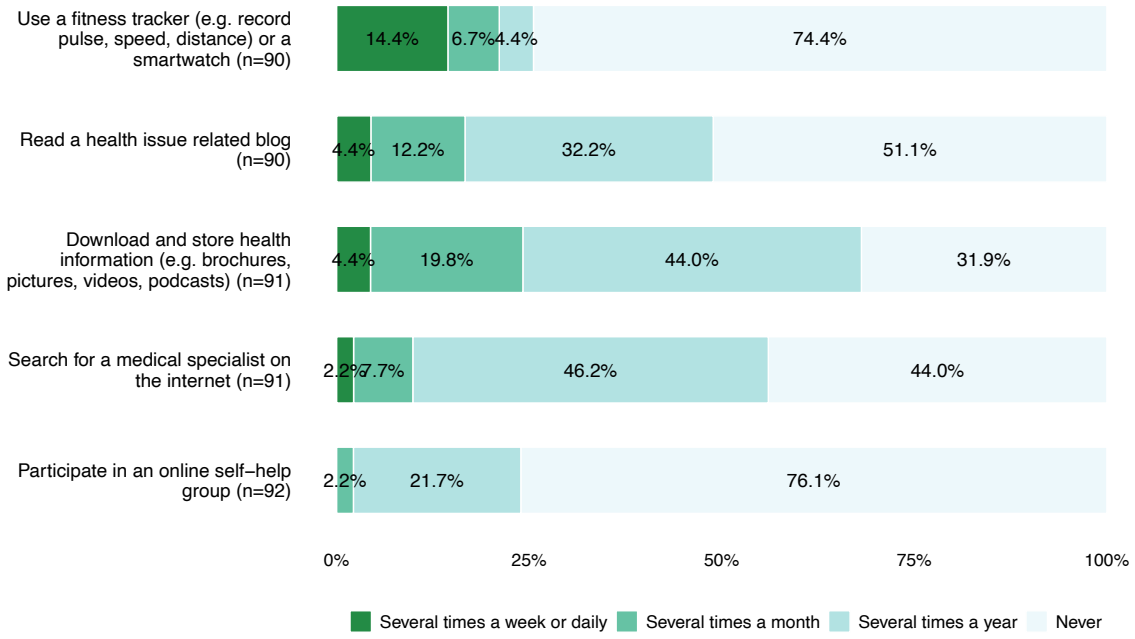


Figure 5. Internet use of patients for health care



6.5.3 Qualitative results

Patient/professional eHealth perceptions and needs (i.e., eHealth literacy and services) are described in six themes: *"considering non-ICT-accessible groups"*; *"fitting patients' and professionals' technology"; "providing timely, understandable, and safe information"; "empowering end-users in ICT and health decision-making skills"; "addressing perceptions of end-users";* and *"putting people at the centre of technology"*. These themes are described and illustrated (i.e., participant quotes) in a joint display with key quantitative findings for each eHealth literacy dimension (**Table 4**).

6.5.4 Synthesis of findings on eHealth literacy domains

Access

Patients and healthcare professionals seem to be well equipped with hardware to access ICT and eHealth. However, our findings indicate it is important to consider those who are lacking ICT access when developing new eHealth services. Additionally, we need to consider interoperability to ensure that applications are fully supported by both patients' and professionals' devices and operating systems.

Understand and appraise

While patients and professionals feel confident using familiar technologies, they express needing guidance in understanding and appraising ICT/eHealth information. Valid, reliable information is key for empowering end-users to make high quality decisions (i.e., informed and aligned with values and preferences) for themselves or with their patients.

Apply

Most patients and professionals lacked experience with eHealth support (e.g., apps, online forums, self-help groups), causing uncertainty and a variety of concerns. Involving stakeholders early in the development process is important for achieving user-centred design and supporting successful integration of onsite care and patient supports.

Table 4. Joint display of key quantitative and qualitative findings for each eHealth literacy dimension

Main quantitative results	Description of qualitative themes	Representative quotes
Access	***Theme 1. Considering non-ICT-accessible groups***	
Patients - High level of internet access (90.1%) - Devices to go online available (e.g., 80.2 % smartphone) Health professionals - Equipped by their employers with laptops (80.9%) or desktop computers (85.1%), rarely smartphones (4.3%)	- Experts were surprised about the high level of access to ICT. In their perception, access or internet connection is often problematic. Mainly patients >75 years old or some not interested or capable are discussed to be insufficiently equipped and literate to use ICT. - Experts emphasized that the needs of the non-ICT-accessible group of patients must be taken into account when developing a model of care.	- *«I am now surprised that many are already so well equipped with the internet. That (MANOSS results) surprised me a lot. Because of the COVID situation the feedback I got was obviously different. But I can't verify that, it's just a subjective impression.»* (Nurse, national expert group) - *«In our (…) project, we notice the cut in accessibility, which is around 80 years old. Those up to 75 are very accessible online, (…). But it's like this, you mustn't forget the others. At some point during this Corona period, we also realised that.»* (Physiotherapist, national expert group)
	Theme 2. Fitting patients' and professionals' technology	
	- Experts explained that patients' smartphones often do not have the capability to do video conferencing. - Experts discussed that professionals are limited by ICT available at workplace and do not want to use their private devices for communication with patients. - Experts agreed that for good acceptance, new eHealth solutions need a good fit with both patients' and professionals' devices (provided by the hospital).	- *«And (…) some phones do not have the capability to do visual.»* (Occupational therapist, international expert group). - «We have the same experience, email works great. Resistance would certainly exist with technology that is not available from the hospital. Almost everyone here has an iPhone, but they are not willing to use it for patient (contacts). These are the technical hurdles, which would have to be overcome by professional devices.*»* (Nurse, national expert group)
Understand & appraise	***Theme 3. Providing timely, understandable, and safe information***	
Patients - Relatively high rating of comprehension of eHealth information ($\bar{x}$=6.7, 95% CI: 6.2 - 7.3) - Less confident evaluating reliability of eHealth ($\bar{x}$=5.8, 95%	- Experts discussed that because of patients' diversity a range of information offers (technology based and not) need to be accessible. - Experts explained that due to the variable SSc progress and course, online information and pictures can be frightening for patients. Experts described patients' difficulties of navigating appropriate and safe information over time. In particular for SSc self-management, pragmatic and practical information is rare.	- *«When we developed our self-management program, (…) we did ask them what kind of format would they like, and very surprising for us, because we thought that everybody wanted an internet program, what a lot of people wanted was a book. (…), some people find it easier and we didn't really see that this was depending on age. That was kind of interesting.»* (Occupational therapist, international expert group) - *«That (Google search) is still really frightening. (…) The information is better than it was, but I think it is still horrifying for people.»* (Patient, international expert group) - *«Side effects of medicines: are often not bad but annoying. What can I do then? A visit to the doctor would often not be necessary but there is no information source/reference*

CI: 5.1 - 6.4) and finding health apps ($\bar{x}$=4.8, 95% CI: 4.2 - 5.4) - Online offers seldom raised their medical knowledge ($\bar{x}$=4.3, 95% CI: 3.7 - 4.9) or helped for making health decisions ($\bar{x}$=3.9, 95% CI: 3.4 - 4.5) <u>Health professionals</u> - Felt able to assess reliability of eHealth ($\bar{x}$=7.2, 95% CI: 6.6 - 7.8), which improved their knowledge ($\bar{x}$=6.3, 95% CI: 5.4 - 7.1) - Do not feel very confident in finding health apps for their patients ($\bar{x}$=5.5, 95% CI: 5.0 - 6.1) - Rarely use online information for making decisions about the health of their patients ($\bar{x}$=5.0, 95% CI: 4.3 - 5.6)	- Experts stated that patient organisations are good information sources for professionals as well, especially for people who do not know much about SSc. - Experts agreed patients need information tailored to their understanding of SSc and self-management. The information provided should encourage people's coping of living with a rare condition by taking down the medicalization of the disease. Professionals could guide patients to find appropriate information, but need to be educated about patient information themselves.	*book especially for systemic sclerosis where I can find out what can be done about it. Doctor visits could be saved.»* (Patient, quantitative, open text) - *«One of the ways we tried to overcome the fear factor was the Wikipedia page on the rare condition that I work on. It is actually managed by the head of the patient organization. (…) And we found that really helped change peoples' perceptions in the last couple of years. We partner with him (patient) to make sure that the information and data is updated regularly. But we found that was very helpful for kind of taking down the medicalization of it and really thinking of it as a human experience of living with a rare condition.»* (Nurse, international expert group)
	Theme 4. Empowering end-users in ICT and health decision-making skills	
	- Experts discussed that patients who are afraid to learn how to use new technologies, but also professionals with a low affinity towards ICT can be limiting for eHealth implementation and use. - Disease information – even if it is easy understandable – still needs explanation for patients. Not everything is going to happen to everybody and some decisions are easier if shared by patients and professionals. - Experts agreed that user empowerment is crucial for sustainable ICT implementation. Furthermore, (shared) health decision-making competences need to be trained – by patients and professionals and integrated systematically in technological approaches.	- *«I do not feel able to familiarise myself with the new technologies and learn how to use them.»* (Patient, quantitative, open text) - *«How open am I (to ICT), how affine am I, also in counselling, what experiences have you had yourself, how accessible do you experience it, what impression do you have of the quality? It's very difficult to cut that out. And if I don't have any affinity at all, then it becomes more difficult.»* (Physiotherapist, national expert group) - *«What we would say to new patients, don't read a section if it doesn't involve you. You know, not everything is going to happen to you.»* (Patient, international expert group) - *«Many times we talk about shared decision making, but we never talk about how to do it. There are several tricks, ways to do it. (…) how we could improve it this kind of shared decision making, because it should not stay with a principle.»* (Physician, international expert group)
Apply	***Theme 5. Addressing perceptions of end-users***	
<u>Patients</u> - Used the internet primarily for private purposes (e.g., communication, mobile applications) - 8.8% of internet-users never used it to search for health information, respectively 44% only a few times a year	- Experts reported that patients and professionals have little experience with the use of eHealth services such as apps and internet programs. They can hardly imagine how those technologies are supposed to work in their clinical practice. - Out of this uncertainty experts formulated end-users concerns, such as lacking human, financial and time resources. Especially the patients concerned about data security and becoming dependent on ICT. - Experts agreed that eHealth services need to be well planned and adjusted to the existing clinical procedures, but also to the personal and financial conditions. To achieve this, end-users'	- *«I mean what I do personally, I communicate a lot with patients by email and that works. That works. But on the other side now, if we're just talking about communication, exactly, you can ask yourself, do you have the resources through an app or is there a person in charge then? How do you want that to work?»* (Rheumatologist, national expert group). - *«If you ask the rheumatologists, they fear the workload that is associated with it (…) Certainly, every stakeholder sees the potential, but every stakeholder has some fears or requirements.»* (Rheumatologist, international expert group) - *«I am still wary of too much data shared with the health insurance companies.»* (Patient, quantitative, open text)

- Indicated relatively little experience with web-based self-management support. Online support groups and forums were rarely (21.7%, 14.4%) or never (76.1%, 83.3%) used. <u>Health professionals</u> - Used the internet at least weekly to send and/or receive e-mails (95.7%) or search for information on diseases/therapies (72.3%). - Used email weekly for patient communication (40.4%) - Rarely used the internet weekly for reminding patients of an appointment (14.9% weekly), and for discussing in online forums with patients (2.2% several times a year) - Rarely used either eHealth apps in their private life (42.5%) and recommended them to their patients (29.8%)	worries need to be taken into account by engaging stakeholders in the development process.	- *«The most powerful uptake of this (fears), is to engage stakeholders in the development process, so including patients in the development process and also to underscore that this is going to help relieve workload for healthcare providers, and try to extend their care rather than replace it.»* (Nurse, international expert group)
	Theme 6. Putting people at the centre of technology	
	- Experts emphasized the fears of patients and professionals loosing interpersonal interaction and relationship because of ICT use. - During the COVID-19 pandemic they realized that online contacts are working and relieving – even if they did not know each other before. - Experts discussed that eHealth programmes and onsite care need to be closely linked (e.g. contents of eHealth programmes to be taken up in clinical visits) - Experts agreed that eHealth is an additional way of giving care, not a replacement of all or most of the visits. Optimally it is closely linked and coordinated with onsite care for example in SSc symptom management.	- *«I am against any digitalisation - a personal relationship with a professional is/would be important in the recovery process. Today's tendency to digitalise everything is extremely annoying and I hope that this will not progress even more in the health sector.»* (Patient, quantitative, open text) - *«Corona has probably also pushed the whole thing a bit. As a high-risk patient, I wasn't allowed out and they weren't allowed to receive patients either, so it was partly via video conference or telephone. This wasn't bad at all. I simply have to reserve this hour and I don't have to stay there for 1.5 hours and then come back.»* (Patient, national expert group) - *«The most important findings were, that this (eHealth) is seen as an additional way of giving care, intermittent and mainly patient-driven, when patients feel the need for additional questions, additional topics to be discussed, and not as kind of replacement of all or most of the visits»* (Physician, international expert group) - *«We know from SCQM (i.e., Swiss registry for inflammatory rheumatic diseases) that it is very much hoped, especially when it comes to symptom tracking, which can also be a part of dealing with the disease, that it would be quite decisive that in the consultations, really what people have followed over a certain period of time, that this is taken up. That the doctors look at it with the patients and if they were in a nursing consultation or physiotherapy/occupational therapy, that someone looks again at what was during this time, what they have monitored.»* (Physiotherapist, national expert group)

6.6 Discussion

This explanatory mixed methods study examined SSc patient and healthcare professional eHealth literacy providing a deeper understanding of perspectives and needs for integrating web-based chronic care support. Notably, while technology is omnipresent in daily life, patients and professionals alike reported problems of interoperability of technology and indicated need for education to effectively use eHealth applications. Additionally, the problem of equity in access was highlighted.

In respect to ***access***, 89.1% of SSc patients reported using the internet at least weekly – primarily for communication. These results mirror increasing numbers of people, especially older people, gained access to ICT/eHealth.[33] In Switzerland, more than 90% of people use the internet – including more than half of people 75 years and older.[34] However, our qualitative findings indicate the need for inclusive systems that are accessible to people with and without ICT access. In line with our findings, a European evaluation of more than 180 eHealth programs/applications supporting integrated care for individuals with multiple morbidities highlighted eHealth barriers including insufficient ICT infrastructure and interoperability problems.[35]

We found that ***understanding and appraisal*** of eHealth in SSc is complicated by two interrelated factors – low quality online information (as reported by focus group participants) and lack of confidence in using eHealth information for health decisions (as indicated by survey findings). We identified relatively low levels of perceived competency among SSc patients and healthcare professionals in decision-making based on online information. These observations are similar to studies in cancer patients.[28, 36] Patients with cancer as well as SSc indicated difficulties in locating valid, reliable internet content to support decision-making. Evaluation of online information is complicated by the low quality and sometimes false, frightening information on the web. Similarly, the variable disease trajectory of SSc and the many healthcare specialists involved can make it challenging for individuals to apply information to their specific SSc concerns. Participants in the present study echo challenges faced by rare disease patients worldwide,[37, 38] underscoring the importance of providing valid, reliable information that relates to an individual's disease course and health decision-making needs (i.e., patients and healthcare professionals). Importantly, our findings indicate that SSc patients and professionals who care for them need guidance and support to better understand and appraise eHealth information/technologies. The eHealth-enhanced chronic care model recognizes eHealth education as a critical component for chronic disease management[2] yet theory-driven programs to enhance end-users eHealth literacy is frequently lacking.[35, 39] Melchiorre et al.[35] evaluated eHealth within integrated care programs and found that half of programs provided healthcare professional training – yet few addressed patient training needs. Thus, recommendations guiding eHealth services are needed to generate a shared understanding of disease impact and self-management support.[40] eHealth should be built on a scaffold of resources and information to support a shared illness perception and high quality decision-making for patients and professionals alike.[41] Key relational functions of eHealth applications include facilitating patient-provider communication, supporting shared decision-making and assuring productive technology-based interactions.[2, 24]

In respect to ***apply***, the present study highlights application as a critical roadblock to eHealth implementation for patients and professionals. Patients cited ethical, legal and social concerns (i.e., data security, dependence on ICT, loss of interpersonal interactions) while providers noted logistical barriers (i.e., lack of personnel, resources, time). Such concerns have been identified as factors limiting end-user

acceptability and engagement sustainability of eHealth services.[6, 42] Nevertheless, our focus group discussions conducted during the quarantine imposed by the COVID-19 pandemic revealed positive attitudes about the utility of online support. Respondents expressed surprise about the quality of the online contact – even if they had not met the other person. Congruently, data from patients with chronic lung diseases show that experience using eHealth can demystify ICT and is associated with more positive attitudes about the usefulness of eHealth resources.[43] Thus, providing SSc patients and healthcare professionals with more ICT/eHealth experiences may help create more positive attitudes and beliefs – especially in relation to peer-led support groups. Lack of knowledge about what happens at support group meetings and not having reliable transportation to attend meetings are common barriers for SSc patients.[44] One way to surmount such barriers is to utilize online groups to overcome geographic distance. Indeed, existing literature support the notion that rare disease patients can benefit from online peer-to-peer support and mentorship.[45] Shaping patients' and healthcare professionals' attitudes may foster eHealth implementation. Specifically, providing guidance for using eHealth, as well as data supporting its utility for improving outcomes, can shift current perspectives and proper uptake of eHealth interventions.[46]

Additionally, our qualitative inquiry revealed user-centredness and equity as critical elements in developing eHealth-enhanced models of care. Participants highlighted the need to link eHealth and onsite care to ensure that resources are equitably accessible by individuals who lack ICT, have limited digital literacy (e.g., less educated patients) and/or are geographically dispersed. For example, digital care for older adults may be most effective using a hybrid format (i.e., combination of digital and in-person presence).[47] It is worthwhile to note that videoconferencing (e.g., for home-based groups) is feasible even for those with limited eHealth literacy as long as appropriate ICT infrastructure and eHealth training are provided.[48] Importantly, eHealth may not directly reduce staff and costs[49] and is intended as a complement to care rather than a means to replace current practices.[50]

Relative strengths of this study include diverse data sources (i.e., quantitative and qualitative) from a range of stakeholders that were geographically diverse (i.e., within Switzerland and Europe/ United States of America) and spanned a range of experience with SSc. It merits mention that some expert patients had professional backgrounds including health policy, medicine, nursing and/or biomedical research thus may not be representative of all SSc patients. A limitation of the quantitative survey is the Swiss sample, making it difficult to broadly generalize our results internationally. The international focus group largely supported our findings. However, only one patient participated in the international focus group so caution is warranted in generalizing findings more widely. Furthermore, we did not include general practitioners and non-rheumatology specialists in the focus groups what limits conclusions that can be made regarding multi-professional management. Further research is needed to better understand and improve eHealth literacy and multi-professional support in SSc patients. Importantly, such work could include the European Reference Network on Rare and Complex Connective Tissue and Musculoskeletal Diseases (ERN ReCONNET) to increase generalizability.[51] Moreover, measuring eHealth literacy is challenging as validated instruments have not been updated to fully address the current state of platforms (i.e., social media) and internet use patterns.[26, 27] While rare disease populations have been considered internet "power users", no tools specifically address the unique ways that rare disease patients use the internet to learn about their condition and crowdsource solutions.[52] Future research may focus on eHealth literacy in broader rare disease populations to determine if findings are SSc-specific or representative of experiences of rare disease patients more broadly. Additional investigation may focus

on the active role of SSc patients in designing eHealth-enhanced care (i.e., co-creating solutions).[53] It would be important to know the optimal model of care to empower and support active involvement of patients and coordinate disease management across multiple healthcare professionals involved in the care pathway.

6.7 Conclusions

To develop an eHealth-supported model of care, the interoperability of patient and provider technology is foundational. Both patients and healthcare professionals could benefit from structured, systematic eHealth guidance and training to help them identify valid, reliable and pertinent patient information. A key aspect of eHealth-supported models of care is to facilitate patient-provider communication to support shared decision-making and self-management. To ensure equity, design must also consider those individuals who have limited eHealth literacy and/or lack access to ICT.

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Chapter 7 Discussion

Within this last chapter, the key findings of the four articles are summarized (**chapter 7.1**) and discussed in light of the existing evidence and implications for clinical practice and policy (**chapter 7.2**). This is followed by a reflection on the strengths and limitations of the methods used and recommendations regarding future research (**chapter 7.3**).

This dissertation contributes to the existing body of knowledge by identifying four target areas for system change, all of which are vital for the reorganization of systemic sclerosis (SSc) care toward an eHealth-facilitated integrated care model: 'shared and informed decision-making' (chapter 7.2.1); 'complex care coordination' (chapter 7.2.2); 'self-management and psychological support' (chapter 7.2.3); and 'monitoring of integrated care programs' (chapter 7.2.4). These topics are connected by their particular contributions to specialised, accessible and patient-centred care that leaves no one behind [1] (**Figure 1**).

7.1 Synthesis of key findings

The Chronic Care Model (CCM) is a longstanding and widely used model that incorporates eHealth approaches to guide the development of new models of care.[2-4] Such models have been successfully implemented for highly prevalent chronic diseases including asthma, cardiovascular disease, depression, diabetes and osteoarthritis, and have been shown to improve patient health outcomes.[5, 6] To our knowledge, as no model of care has yet been tested for patients with SSc; little is known about how CCM elements can be implemented within their routine care. Additionally, little is known about SSc patients' and providers' electronic health (eHealth) literacy, which is a prerequisite to successful use of eHealth components within chronic care. This dissertation provides a comprehensive understanding of current chronic illness management for SSc in Switzerland, as well as eHealth literacy and use from the perspectives both of patients living with SSc and of healthcare professionals (HPs). The evidence it has gathered will help identify needs and gaps in SSc care, thereby supporting the development of an eHealth-enhanced rare disease chronic care model for patients with SSc in Switzerland.

The MANagement Of Systemic Sclerosis (*MANOSS*) study protocol (**chapter 3**) describes the procedures we used to develop an integrated model of care for patients living with SSc in Switzerland and their families. All are based on contextual analysis and stakeholder involvement.[7] The *MANOSS* study's participatory approach is essential to fit the model to the contexts of patients with SSc in this setting.

To overcome the inherent challenges of working with geographically dispersed rare disease patient populations, patient-reported outcome measures (PROMs) and experience measures (PREMs) allow accurate collection of responses to patient-identified health concerns and care experiences. Therefore, we needed to adapt and sometimes translate and validate the selected instruments to measure health-related quality of life (HRQoL), chronic care and eHealth literacy within our specific study population.

For example, **Chapter 4** describes the revision and validation of the German version of the 29-item Systemic Sclerosis Quality of Life Questionnaire (SScQoL).[8] Rasch analysis was employed to test the revised instrument's validity, reliability and unidimensionality. We concluded that the revised German SScQoL, with its 4-point response structure, is a valid and reliable measure. Our analysis indicated that the scale was well targeted, had high internal consistency (Person Separation Index, PSI=0.931) and worked consistently in patients with diverse demographic and clinical characteristics.

Additionally, **Chapter 5** describes how we validated the Patient Assessment of Chronic Illness Care (PACIC) using the Mokken model.[9] Notably, as the PACIC has not previously been used in the context of SSc, it is unclear how well this generic instrument assesses challenges specific to rare disease care (e.g., shortages of treatment options and specialized healthcare professionals). Our validation revealed five items of the PACIC-20 dimensions that did not fit our data.[10] After excluding these items, H coefficients were strong both for the global instrument (0.52) and for each subscale (0.69, 0.70), suggesting a robust unidimensional scale. These results are discussed in more detail in **section 7.2.4**, which addresses the monitoring of improvements in integrated care.

One central aim of our contextual analysis was to describe current chronic illness care and eHealth literacy and needs (from patient and provider perspectives) as a base for SSc care model development. **Chapter 5** presents an explanatory sequential mixed methods analysis of the current state of SSc chronic illness care and HRQoL from the patient perspective.[10] The quantitative phase (n=101) of this analysis evaluated the level of chronic care across the five dimensions measured by the PACIC scale, plus quality of life measured by the SScQoL.

The quantitative results informed the subsequent qualitative phase. Based on interview data from 8 SSc patients, that phase helped explain care experiences of people living with SSc in terms of the PACIC dimensions. The mean overall PACIC score was 3.0 out of a maximum score of 5 (95% CI: 2.8–3.2, n= 100), indicating that care was 'never' to 'generally not' aligned with the CCM.

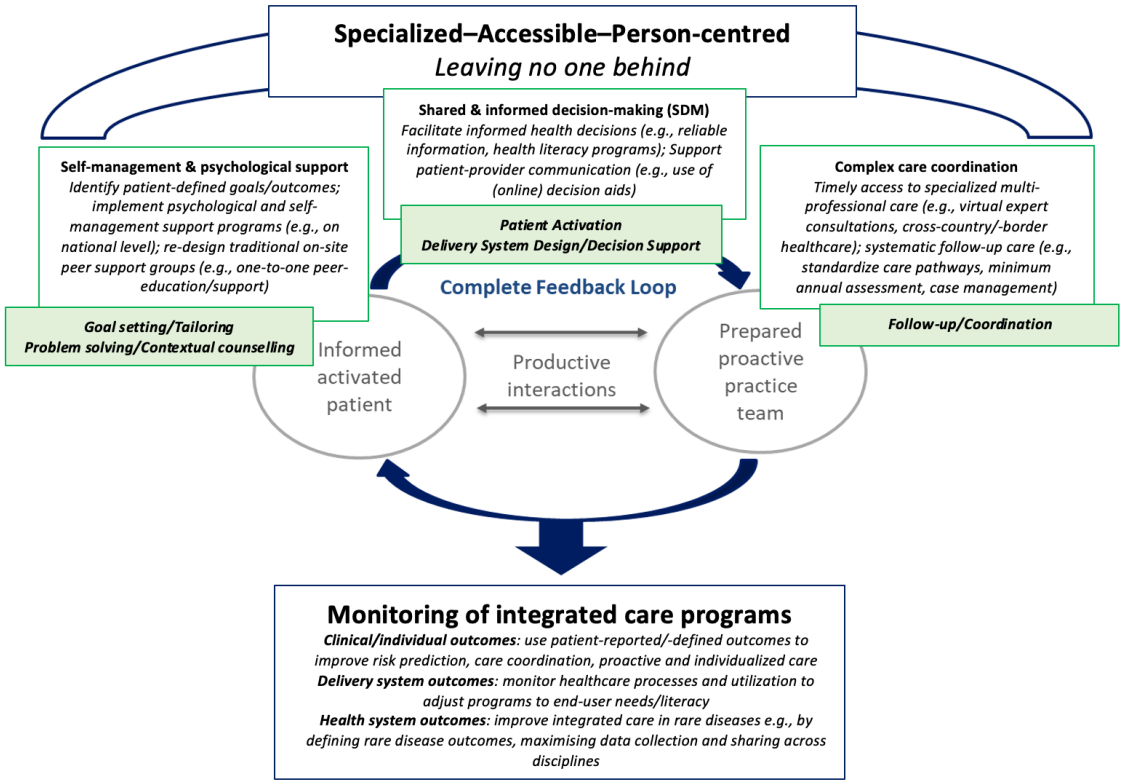
Overall, we identified relatively low patient ratings of chronic care regarding two key elements of chronic care not yet systematically implemented in SSc management: shared decision-making and self-management support. These quantitative findings matched our qualitative data, with revealed patients within this population frequently encounter major shortcomings in care, particularly *experiencing organized care with limited participation*, *not knowing which strategies are effective or harmful* and *feeling left alone with disease and psychosocial consequences*. Accordingly, patients responded to challenges by *dealing with the illness in tailored measure*, *taking over complex coordination of care* and *relying on an accessible and trustworthy team*. These results highlight the need for systemic changes regarding three dimensions: 'shared and informed decision-making', 'self-management and psychological support', and 'complex care coordination'.[10]

To inform integration of eHealth into a new model of care, the explanatory sequential mixed methods study described in **Chapter 6** assessed SSc patients' and healthcare providers' eHealth literacy and needs regarding web-based support that relied on internet-based information and communication technologies (ICT).[11] The quantitative phase included patients (n=101) and HPs (n=47); the qualitative phase used focus groups composed of Swiss/international patients (n=4), family members (n=1) and HPs (n=12). Quantitative results revealed that patients generally have difficulty gauging the quality of eHealth information, and that both patients and HPs rarely use online information for health and care decisions. The focus groups revealed that two dimensions— *considering non-ICT-accessible groups* and *fitting patients' and professionals' technology* —are crucial both for access to care and for implementation feasibility. In relation to understanding/appraising eHealth, participants highlighted that general SSc information is not tailored to individuals' disease courses. Recommendations included *providing timely, understandable, and safe information* and *empowering end-users in ICT and health decision-making skills*. Professionals expressed concerns about resource deficiencies (e.g., time, infrastructure). Patients were concerned about data security and person-centredness. Key eHealth drivers included *addressing end-user perceptions* and *putting people at the centre of technology*. As noted for **Chapter 5**, these results confirm the need to shift the focus of care towards an integrated care approach that promotes shared decision-making skills. Moreover, the results of **Chapter**

6 highlight patients' and HPs' current needs regarding eHealth literacy and use. Our analyses indicated needs not only for interoperability of patient and provider technology, but also for targeted person-centred programme development and training to support the uptake of eHealth in SSc care.[11]

Overall, our contextual analysis revealed major shortcomings in the integration of four care practices: (1) shared and informed decision-making; (2) self-management and psychological support; (3) complex care coordination; and (4) monitoring of integrated care improvements (**Figure 1**). The related needs and suggested interventions for care improvement are discussed in the following two chapters and summarized in **Table 1**.

Figure 1. The eHealth Enhanced Chronic Care Model (eCCM) developed by Gee et al. (2015)[3] adapted for Systemic Sclerosis



7.2 Target areas for system change for eHealth-facilitated integrated care

Integrated care, as described by Hughes et al. (2020)[12], is an 'emergent set of practices intrinsically shaped by contextual factors' rather than a single intervention or a form that fits all.[12] At the same time, any systemic change towards integrated care should aim to bridge the gaps between patient needs and existing care by adopting a person-centred rather than an organisation-centred focus.[1, 12] Accordingly, our research identified four target areas that require systemic reorganization and improvement to implement eHealth-facilitated integrated care for SSc: 'shared and informed decision-making'; self-management and psychological support', 'complex care coordination', and 'monitoring of integrated care programs' (**Figure 1**). Each of these target areas requires *micro-* (clinical: participation by consumers in co-care), *meso-* (delivery system: infrastructure and competencies/training of HPs) and *macro-level* (health

system: organization, health policy and socioeconomic factors) changes.[12] The target areas are summarized in **Table 1** and discussed below.

Table 1. Target areas for system change to implement eHealth-facilitated integrated SSc care

1. Shared and informed decision-making			
***What needs change* according to our study results?**	***How can we change our practices* according to study results and literature**		
	Micro (clinical)	Meso (delivery system)	Macro (health system)
Facilitating (technology-based) informed health decisions			
- Patients report difficulties locating and evaluating (online) information supporting the shared decision-making (SDM) process[11]	- Explore patients' understanding and preferences regarding their disease[13] - Provide reliable information that relates to an individual's disease course and health decision-making needs[10, 11, 13]	- Implement (e)health literacy programs to improve patient (e)health literacy and shared decision-making skills[14-16] - Educational videos can be effective to explain complex content to patients[17]	- Support a national web-based information hub/platform for patients and professionals (example: www.scleroderma.org)[18] - Partner with patients to develop information materials that meet their needs[19]
Supporting patient-provider communication			
- Patients experience limited participation in consultations and organisation of their care[10]	- Ensure a collaborative approach between patients and HPs[10, 11] - Protect patients from feeling overwhelmed in managing their SSc[10] - Provide/suggest online decision-making aids complementary to face-to-face consultations[10, 20]	- Support SDM via information and technology (e.g., patient decision aids, online information platforms)[20]	- Personal health records (PHRs) managed by patients may (potentially) help to improve patient-provider communication[21] - Ensure data security of PHRs[11]
- HPs lack guidance and technical support to use SDM with patients[11]	- Develop a common understanding of SDM with patients within interprofessional teams[10, 20]	- Provide guidelines that encourage and define SDM[22] - Install educational programs for HPs that train them in SDM and eHealth skills[22]	- Support professional bodies and universities to inform HPs' curricula using a holistic chronic disease framework such as the eCCM[23]
2. Self-management and psychological support			
Identify patient-defined goals/outcomes			
- Patients lack specific goals and a treatment plan based on their individual problems, which would improve self-management and	- Define individual health goals/target outcomes and treatment plans together with the patient to minimize his/her main SSc manifestations and consequences[10, 24]	- Rethink care delivery and train patients and HPs for patient-defined goal-setting and joint treatment planning with the patient[24, 25]	- Support professional bodies and universities to inform HPs' curricula using a holistic chronic disease framework such as the eCCM[23]

health-related quality of life (HRQoL)[10]	- Implement annual evaluations with the emphasis on HRQoL and individual goals [18]	- Focus more on patient empowerment and non-pharmacological care[18]	
Implement psychological and self-management support programs			
- Patients lack guidance and effective strategies for independent self-management[10] - Variable SSc disease trajectories and the many HPs involved make it challenging for individuals to apply information to their specific concerns[10, 11] - eHealth interventions must consider those individuals who have limited eHealth literacy and/or lack access to ICT[11]	- Assess each patient's (e)health literacy[11] - Provide comprehensive tailored self-management support to target each patient's (e)health literacy, disease stage and consequences[10, 11, 26] - Ensure direct access to specialist counsellors (e.g., nurses, psychologists), self-management programs and peer support[10, 15, 26] - Use of technologies (e.g., webinars, advice line, virtual consultations, eHealth, web platforms) that provide accessible support[11, 27]	- Implement interventions that address anxiety /depression but also (e)health literacy/use and coping with the disease for mixed patient populations[11, 15, 28] - Promote roles that ensure support along the entire care pathway (i.e. from hospital to home)[10] - Train HPs on the full range of support available to patients (e.g., outside hospitals) and how to provide self-management support[26]	- Support the development (or adaptation) of a self-management program for SSc[29] - Support patient involvement in program development/ provision[19] - Provide funding for development, implementation and evaluation of self-management programs for SSc and other rare diseases[27]
Re-design traditional on-site peer support groups			
- Patients do not perceive self-help groups as a source of support for problem solving and mention limitations of on-site peer support groups[10]	- Ensure individual one-to-one peer-led support, e.g., to prepare consultations with the physician[18, 30] - Ensure that peer counselors and group leaders receive training, structured consultation guidelines and supervision[30, 31]	- Foster the implementation of peer counsellors for rare disease patients in national centres of expertise[30, 32, 33] - Improve information and awareness about peer support groups[31]	- Support (re-) organization of peer-led support on a national level to improve accessibility and individualization, e.g., by online and/or in-person peer-to-peer support[10, 31, 34] - Support involvement of SSc patients in designing and delivering their own support[35] - Develop guidelines for structured peer counselling[30]

2. Complex care coordination			
Timely access to specialized multi-professional care			
- Patients often assume responsibility for complex care coordination[10] - They lack cross-professional and cross-speciality guidance[10]	- Strive for a multi-professional approach that focusses on a joint treatment plan (i.e., HPs from several disciplines together with the patient) through education/ coaching[1, 10, 25, 36-38] - Embed psychologists within clinical teams[26] - Consider virtual expert consultations and cross-country healthcare collaborations to improve access to specialized care[1] - Support co-management (i.e., of patients and HPs) by teaching patients to communicate and advocate more effectively for themselves and others[39]	- Foster local partnerships across healthcare sectors (e.g., between centres of expertise and primary care physicians)[40] - Embed new professional roles that span health and social care[40] - Provide training and financial compensation to facilitate exchanges between primary and tertiary care[18, 38]	- Ensure alignment of SSc care with Quality Criteria for Centres of Expertise for Rare Diseases[33] - Define criteria for HPs' core and specialist competencies in centres of expertise, e.g., required education, composition of multidisciplinary teams[18] - Support development of national care standards to consolidate geographically disparate expertise[41] - Foster multiprofessional collaboration across networks via system-wide policies (e.g., regarding data exchange via EHR) and funding mechanisms[33, 37, 42]
Provide systematic follow-up care			
- Patients lack systematic follow-up care, e.g., they rarely have contact with their HP after a visit[10] - They lack treatment plans to follow at home (with respective feedback from their HPs)	- Implement standard pathways and defined collaboration structures for shared care[18, 43] - Improve early referral to centres of SSc expertise[44] - Conduct (at least) annual systemic assessments of organ involvement and psychosocial consequences[10, 45] - Arrange for case-management, e.g., by an advanced nurse practitioner[38]	- Foster technology that ensures the co-management with patients (PHRs, tools for symptom assessment and self-referral)[18]	- Provide resources to optimize rare disease follow-up care at a national/international level[1]: (1) Sponsor comprehensive disease-specific recommendations[45, 46] (2) Promote/fund rare disease initiatives (e.g., eHealth resources) (3) Support more seamless cross-border care (i.e., for patients from countries without specialized SSc HPs)[1]

3. Monitoring of integrated care programs			
- SScQoL, PACIC, eHealth literacy scores may be valuable when monitoring and evaluating eHealth-facilitated integrated care[8, 10, 11] - There is no confirmed association between PACIC and HRQoL scores[10] - Patients with less education report poorer understanding of health-related information, which may target the understanding of PROMs and PREMs[11]	- Use PROMs/PREMs at the individual level to improve continuity of care (e.g., sharing data between providers)[47, 48] - Use PROMs for individual risk prediction and pro-active care, e.g., technology to tailor care[48, 49] - Consider brief screenings for various health-related issues, e.g., health literacy[50] - Define individual outcomes including patient-defined outcomes[10, 48, 51] - Discuss measurement outcomes (e.g., regarding patients' tracking of their own symptoms) during consultations[11]	- Involve end-users (e.g., patients, HPs) at an early stage of program development for co-design of program monitoring[52, 53] - Plan and adjust eHealth services to match existing procedures/ resources[11] - Focus monitoring on changing health care processes and utilization[11, 54], e.g., productive patient-physician relationships, multidisciplinary structural collaboration, provision of treatment according to SSc guidelines[55]	- Maximize possibilities for data collection and sharing via registries (e.g., EUSTAR) and networks (e.g., ERN ReCONNET)[1, 48, 56, 57] - Support legislation to ensure privacy and protect data[1, 48] - Invest adequately in education on data collection and utilization across disciplines and borders[1] - Acknowledge that, at an international level, enjoyment of life is seen as an important outcome of integrated care[53]

Note. ICTs = (Internet-based) Information and Communication Technologies; PROMs = Patient-Reported Outcome Measurements; EUSTAR = European Scleroderma Trials And Research

7.2.1 Shared and informed decision-making

Current care policies specify that, wherever possible, decision-making processes should be shared between patients and health professionals. This principle, which emphasizes the patient's active role in managing their health, is a central element of person-centred care, an approach widely accepted by patients and health professionals alike. However, the results of two of our studies (**Chapters 5 and 6**) add to the evidence that patients living with SSc are commonly excluded from many such processes.[10, 11, 13]

The PACIC subscales for *Patient Activation* (i.e., actions that solicit patient input and involvement in decision-making) and *Delivery System Design/Decision Support* (i.e., actions that organize care and provide information to patients to enhance their understanding of care) capture the implementation of shared decision-making.[9] Like Desmedt et al. (2018)[58] and Stuber et al. (2018),[59] we observed relatively high PACIC scores in these two dimensions—suggesting that people with SSc generally feel involved in care decisions. Compared to the overall European population of rare disease patients, Swiss SSc patients are more likely to 'receive treatment choices to think about' ($\bar{x}$=3.2 vs. 2.8).[27]

However, the qualitative themes described in **Chapter 5**—*experiencing organized care with limited participation* and *dealing with the illness in tailored measure*—revealed patients' wish for more individualized and shared management of their disease.[10] Patients typically described their care as poorly adapted to their individual

needs and concerns (e.g., travel times, concerns about therapies) and expressed a lack of voice, not only in terms of decision-making, but also concerning the organization of their care. This deficit resulted in consultations and follow-up planning that were mainly provider-driven. Similarly, in a recent qualitative study investigating patient, HP and carer perspectives regarding the interprofessional management of SSc-interstitial lung disease (SSc-ILD), Denton et al. (2021)[25] identified a range of patient concerns (e.g., prognosis, mortality, day-to-day management of symptoms, social consequences, work) left unspoken during consultations with HPs. As a result, patients remained unnecessarily uncertain and anxious about their future. And where HPs fail to learn which disease- and care-pertinent challenges are most relevant to their patients, they are unable to develop shared goals and treatment plans to overcome those challenges.

In addition, our studies (**Chapters 5 and 6**) revealed that, for people with SSc, informed decision-making is additionally complicated by two interrelated factors: low quality, poorly-timed and sometimes frightening information (as reported by our focus group participants); and lack of confidence in using web-based information for health decisions (as indicated by survey findings).[10, 11] Our quantitative study assessing how patients with SSc access, understand, appraise and apply web-based health information (**chapter 6**) showed a high prevalence of patients with low confidence in their ability to evaluate online information.[11] This finding is particularly important as the ability to understand and appraise health information (i.e., health literacy) is the foundation of informed decision-making, particularly regarding such a complex and multifaced disease.[13]

Another recent study, this one looking at factors associated with patient activation in inflammatory arthritis, found that self-efficacy and health literacy (i.e., respectively 'having sufficient information to manage [one's] health' and 'understanding health information enough to know what to do') were significantly associated with patient activation (using the Patient Activation Measure (PAM)).[15] Moreover, the qualitative theme described in **Chapter 5**—*dealing with the illness in tailored measure*—emphasizes the value of protecting patients from feeling overwhelmed in actively coping with their SSc—a finding that adds considerably to prior qualitative SSc research.[60] Our study's focus group participants agreed that, as general SSc information is not tailored to their individual disease courses, patients might feel shocked, overloaded or frightened by it; therefore, for their own protection (e.g., to avoid stressful hospital visits), refuse certain tests, examinations or interventions.[10, 11]

To overcome impediments to informed and shared decision-making, this and other studies confirm the need to solicit patients' input and involve them in decision-making. For both patients and professionals, supporting high quality decision-making also means ensuring that patients have access to the resources and information necessary to share their illness-related perceptions with their HPs.[13, 61] Therefore, one key path toward improvement involves facilitating the types of high-content patient-provider communication that lead to informed (technology-based) health decisions.

Implications for practice and policy

At the **micro** level, decision-making demands a collaborative approach between patients and clinicians. In this context, collaboration implies that the various HPs of the relevant multiprofessional teams have a common understanding of how shared decisions can be achieved.[11, 20] For HPs, one prerequisite to optimal decision-making guidance is to explore each patient's SSc-related preferences and understanding.[13] Spierings et al. (2020)[13] recommend an approach that involves patients in the decision-making process according to their individual needs and literacy. Additionally, as in previous research, focus group participants of our study highlighted the need for reliable tailor-made information, i.e.,

information that relates directly to an individual's disease course and health decision-making needs, while protecting them from being overwhelmed by its volume or diversity.[10, 11, 13, 25]

At the **meso** level, improving healthcare provider competencies regarding shared decision-making is a key implementation target for integrated SSc care.[14, 62] Our studies, similar to those previously published, highlight the need for practical (e.g., guidelines, education) and technical (e.g., patient decision aids) support methods that facilitate shared decision-making with patients.[11, 22, 63] Clinicians require educational programs that build decision-sharing skills and promote co-management with patients.[13, 22] Conversely, eHealth literacy programs have been shown to improve patient shared decision-making skills and change the nature of their questions to HPs in ways that enable the sharing of health decisions.[14, 16] Stocker et al. (2020)[20] highlighted the need for (online) patient decision aids to support high quality decisions that are both informed by and aligned with patient needs, values and preferences. Not only in SSc but also in other rheumatic conditions, web-based patient decision aids have proved helpful for summarizing high-quality information, fostering more patient-focused communication and letting patients that they have played an active role in the making of medical decisions that affect them.[13, 63-65]

Additionally, shared decision-making requires improvements at the **macro** level, particularly for persons living with diseases as rare as SSc. Not only SSc-specific resources but also guidelines on navigating the care system are difficult to find.[10, 11] In general, national and international patient associations such as the European Alliance of Associations for Rheumatology (EULAR) take responsibility for ensuring that understandable, reliable disease information is available. For rare diseases such as SSc, such offers are often limited or low-quality.[66, 67] In the Netherlands, the Arthritis Research and Collaboration Hub (ARCH) foundation was started as a nationwide effort to improve health care for people with rare systemic autoimmune diseases, including SSc.[18] Their 2018 survey showed that 70% of Dutch patients and 66% of HPs prioritized a central information hub as their main requirement for improvement.[18] Moreover, partnering with rare disease patients to develop patient education materials that meet patient needs was found to improve end-user acceptability, understandability and actionability.[19]

Additionally, personal health records (PHRs) managed by patients may help to improve patient-provider communication.[21] PHRs prove to be powerful tools, for example, when interoperability with electronic health records (EHRs) eases and accelerates information exchange between patients and providers. In Switzerland, such innovations are currently scarcely available: as the eHealth Suisse-coordinated implementation of PHRs has been substantially delayed, PHRs remain to be introduced through much of the country.[68] As they become available, professional bodies and universities will need to ensure that HP curricula incorporate PHRs as part of a holistic chronic disease framework that includes shared decision-making and goal setting.[23, 68]

7.2.2 Self-management and psychological support

People with SSc or other chronic and rare diseases and their families need skills to make day-to-day decisions and self-manage their conditions in ways that maintain or improve their health and social status, their quality of life and their overall well-being.[1, 24] However, to make sound decisions that will solve the problems they identify and improve their quality of life, patients need support developing individualized goals and treatment plans.[24] Our study (**chapter 5**) aimed first to evaluate both patient assessment of chronic care (i.e., PACIC) and health-related quality of life (i.e., SScQoL), then to describe the associations between PACIC and SScQoL levels using quantitative and qualitative data.[10]

The PACIC subscales for *Goal setting/Tailoring* (i.e., acquiring information for and setting of specific, collaborative goals) and *Problem solving/Contextual counselling* (i.e., considering potential barriers and the patient's social and cultural environment in setting up treatment plans) capture the implementation of the most relevant care activities.[9] Overlapping with—or possibly despite—the well-researched needs for comprehensive and tailored education and self-management support in SSc, the lowest PACIC-15 subscale score in our study related to these dimensions (*Goal setting/Tailoring*: mean = 2.5, 95% CI: 2.2–2.7; *Problem solving/Contextual counselling*: mean = 2.9, 95% CI: 2.7–3.2). In other studies in common chronic conditions, the same PACIC dimensions yielded the lowest mean values.[58, 69]

Importantly, in our study, several individual PACIC items revealed major shortcomings regarding self-management support: 73% of patients did not (i.e., never/generally not) receive copy of their treatment plans; 60% were not encouraged to participate in patient support groups; 55% were not helped to plan ahead to manage their condition(s) through periods of difficulty or crisis; almost half of patients received no help either to set specific goals (47%) or to formulate their day-to-day treatment plans (48%).[10] In other European countries, similarities were found in patients living with other rare diseases: these people were rarely helped to plan ahead for self-management in particularly challenging times or directed to disease-specific patient support groups.[27] However, compared to our Swiss SSc respondents, more of those patients received copies of their treatment plans.

Also, HRQoL scores indicated that quality of life was severely impaired in many Swiss SSc patients: their overall mean SScQoL (revised German version) score was 18.3/29 (95% CI: 16.7–19.9, higher values indicating lower HRQoL).[8, 10] In comparison, SSc patients in Poland had a mean SScQoL score of 14.8 (SD: 5.1).[70] These comparisons should be considered with caution, as we have obtained our data via the adapted German version of the SScQoL (**Chapter 4 and section 7.3**).[8] Interestingly, mean SScQoL scores in our study were significantly associated with a number of self-reported comorbidities (depression, gastrointestinal problems and osteoarthritis) but not with PACIC scores. Such findings echo those of studies in common chronic conditions, in which PACIC scores barely correlated with HRQoL (r= 0.15 and 0.23).[58, 69, 71] See also **section 7.2.4,** which addresses the monitoring of SSc chronic care.

Fifteen percent of our study patients (n=15/101) (**Chapter 5**) self-reported having suffered from depression in the last year, while in the Polish SSc study more than 30% indicated a moderate severity of depressive disorder; and in a French sample, 43% of patients met criteria for depression, with 26% indicating moderate-to-severe depression.[10, 70, 72] Importantly, depression correlates positively with anxiety disorders, which are common in SSc.[70, 72] High depression rates are also common across general rare disease populations [28]

Complementing our quantitative findings, the patients' qualitative results revealed gaps in care that pose significant barriers to effective self-management.[10] This was especially true of two qualitative themes: *not knowing which strategies are effective or harmful* and *feeling left alone with disease and psychosocial consequences*. Similarly, prior qualitative work in SSc found that patients often lack guidance and effective strategies for independent self-management—particularly in relation to disease and psychosocial consequences.[60, 73, 74] Indeed, a systematic review of 26 qualitative studies in SSc identified that, despite opportunities to participate in support groups, patients often feel 'alone and misunderstood' (i.e., patient's fearful avoidance of fellow patients, invisible suffering).[60] Similarly, a recent interview study conducted in eight European countries revealed that the majority of SSc patients with SSc-ILD lack specialized paramedical and psychological support.[75]

Traditional on-site groups provide important support and informational resources for people living with SSc (1) to obtain social support, (2) to learn about disease treatment and symptom management strategies, and (3) to discuss other aspects of living with SSc.[76] As these groups depend on trained facilitators, they typically include 11-20 patients and family members to reduce the cost per patient. However, they commonly experience difficulties because of patient nonattendance. Patients' most common explanations for this include (1) already having enough support, (2) not knowing of the groups, (3) not knowing enough about what happens at support groups, (4) not having reliable transportation to meetings, and (5) being uncomfortable sharing experiences with a group.[31] In our qualitative study, we were surprised to learn that the patients did not perceive self-help groups as a source of support for problem solving. And whereas some felt they were still 'too healthy' to join such a group, others experienced participation as an additional emotional strain, for example, because it entailed listening to the others describe their problems.[10]

Considering the problems involved in face-to-face contact, technological innovations play particularly important roles in the development and provision of self-management support for rare disease patients.[19, 77] Our qualitative findings (see **Chapter 6**) revealed the importance of leaving no one behind when using technology (i.e., design must consider individuals who have limited eHealth literacy and/or lack access to ICTs.[11]) For the successful implementation of online resources, then, such innovations must involve stakeholders early in the development process, maximize equity across user groups, and produce high-quality support that is both responsive to patient/provider needs and complementary to face-to-face care/support.[11]

Overall, regarding the care of patients living with SSc, the findings of this thesis underscore and expand on previously identified gaps in self-management and psychological support.[13, 26, 31, 60, 74] Therefore, in terms of integrated care, improvements should aim to identify patient-defined goals, provide treatment plans aligned with patients' individual goals and needs, implement psychological and self-management support programs and re-design traditional on-site peer support groups.

Implications for clinical practice and policy

At the **micro** level, the central focus of the actions suggested above is to optimize patient activation. For this to be effective, patients need guidance first to reveal their priorities and preferences, then to define their individual health goals, and eventually to formulate treatment plans that target their selected SSc manifestations and consequences.[24] Therefore, HPs have to tailor each patient's information and provide support according to their disease stage and readiness.[10, 11] Congruently, our findings (**Chapters 5 and 6**) underscore the need for reliable, easily understandable information that relates directly to each individual's disease course (discussed in **section 7.2.1**).

Once patients have set personal goals, HPs should encourage and support them to achieve those goals by building their self-efficacy, e.g., by developing and, if necessary, augmenting their problem-solving skills.[24] At a very basic level, though, all patients living with SSc need to learn to work with their HPs both to develop a shared understanding of the main issues they face (e.g., physical consequences, psychosocial impacts) and to improve the management of those issues across all involved professions and disciplines.[10, 26]

From the HP's perspective, one commonly-observed problem is that patients tend to hesitate to discuss certain highly significant topics during their consultations with rheumatologists. These include day-to-day symptom management, relationships, family and work.[20, 25] Therefore, from their first meetings with

SSc patients, HPs must elicit and assess issues related to these topics, then work with the patient to define goals/target outcomes and experiences. This will help the HP anticipate the type of multiprofessional approach—possibly including direct access to specialist counsellors (e.g., nurses, psychologists, trained peers)—will be most effective to optimize the patient's treatment. To monitor progress, Spierings et al. (2019)[18] recommend implementing an annual evaluation of patient HRQoL and individual goals.

To provide accessible support, reduce patient travel times and overcome other forms of inequity, HPs also need to consider a growing range of technological solutions e.g., webinars, telephone advice line, virtual consultations, eHealth, web platforms.[11, 26, 27] Therefore, they also need to assess patients' eHealth literacy and adapt their information/resources as necessary.[11]

Moreover, peer-guided self-help interventions may improve HRQoL and other outcomes. A recent randomized trial of a 6-week peer-led self-management intervention—consisting of a self-help book and telephone-based individual peer counselling—significantly improved rare disease patients' acceptance of their conditions, coping strategies, social support and mental quality of life.[30] This success supports Spierings et al.'s (2019)[18] recommendation of one-to-one peer support to prepare for physician consultations. Beforehand, however, it is essential that peer counsellors and group leaders receive training, structured consultation guidelines and supervision to support patient self-management.[30, 31]

At the **meso** level, processes such as outcome assessment, shared decision-making and goal setting, psychological and self-management support require healthcare administrators to rethink care delivery and the training of patients and HPs at the institutional level.[18, 25] As a step in this direction, Spierings et al. (2019)[18] identified patient empowerment and non-pharmacological care as key themes for SSc care improvements. Likewise, Dutch patients reported that more attention should be paid to non-pharmacological care.[18] This theme flows alongside the principle that interventions that not only address anxiety and depression but also support patients in coping with their disease are likely to help improve quality of life in people with rare diseases such as SSc.[28, 70, 72]

Therefore, hospital level programs and interventions (e.g., to boost eHealth literacy) targeting rare and/or chronic disease populations need to be considered.[15, 23, 28] To improve eHealth literacy and use, patients and HPs need opportunities to gain confidence, knowledge and skills with new technologies.[11] The literature suggests that educational programs to enhance end-users' eHealth literacy are frequently lacking.[78, 79] For example, in evaluating eHealth uses within integrated care programs, Melchiorre et al. (2018)[78] found that, while half of the identified programs provided HP training, few addressed patient training needs.

In addition, hospitals need to promote roles that ensure patient support along the entire chronic care continuum (i.e., hospital and home) to ensure seamless and sustainable self-management support.[26, 80] This is particularly true for SSc, a complex condition for which few experts are available. This will also involve a meso-level re-thinking of peer support: for example, the implementation of peer counsellors for rare disease patients in national centres of expertise would very likely help empower patients to cope with their conditions.[30, 32, 33] At the institutional level, HPs may forge collaborations with people with SSc and patient organizations to improve information and awareness about peer support groups. At the same time, they need to be informed not only of methods of supporting patient self-management, but of the full range of available support options, including those outside of hospitals.[26]

At the **macro** level, it is vital to convince healthcare policymakers to fund the implementation of disease-specific (online) self-management programs and peer-led support systems that complement such programs.[29, 76, 81] For Switzerland's SSc population, such self-management programs will require cultural and linguistic adaptation, with early involvement of stakeholders at every stage and goals that include supporting equity and increasing the value of the face-to-face care provided in hospitals.[11, 19] For example, the Taking Charge of Scleroderma (TOSS) internet self-management program, which was originally developed in English, could be adapted for Switzerland.[29, 82]

Furthermore, the Scleroderma Patient-centred Intervention Network (SPIN) is a worldwide organization of researchers, HPs and people living with SSc who aim to develop, adapt and test new and existing SSc self-management programs.[83, 84] Their work covers specific programs to manage symptoms (e.g., hand function, appearance changes), perform daily tasks and deal with illness-related emotions, as well as to balance activity and rest.[85] To ensure that such programs maximally address the needs of individuals living with SSc and their families and reach as many people as possible, all SPIN resources are jointly developed, tested and disseminated online in close collaboration with project-specific advisory teams. These include SSc patients (i.e., patient advocates) and caregivers of people with SSc. To date, SPIN programs have been developed and adapted in English- and French-speaking countries; however, to our knowledge, none are yet available for German- or Italian-speaking countries, which would be essential for their implementation in Switzerland.[84]

Concerning peer-led support, re-organization on a national level would improve current groups' accessibility and individualization of their support—e.g., by implementing online and/or peer-to-peer support.[10, 31, 34] It is also vital to support group leaders in their roles, which **include** *structuring group meetings*, *recruiting new members and fostering a positive group culture.*[85] Currently, a 13-week SPIN network education program for SSc group leaders (SPIN-SSLED) trains them for their roles and contributes to more positive support group experiences.

While a tremendous amount of work remains to be done, we must recognise that, because rare disease patients and their associations have spent decades fighting for recognition and high-quality care, they already number among the health system's most empowered groups [86]. The Swiss SSc patient association is even able to devote resources to building synergies with other patient groups. One example is its national program, which is open to people with other inflammatory rheumatic diseases who want to provide (one-to-one) peer support and counselling.[34] This training provides eligible persons the tools to implement their expert knowledge into roles as recovery facilitators. The SSc patient association's goal is that by the end of 2021, every newly diagnosed person with SSc will have a peer to help them navigate the 'jungle' of living with a systemic disease.

After successfully running the first course, the Swiss SSc patient association who administered it will now turn their attention to implementing systematic peer involvement in the rheumatology clinics.[34] Still, on the national and international levels, as few rare disease patient associations have the resources for such investigations, most need extensive funding to develop, implement and evaluate self-management and peer-support programs for their populations.[27]

7.2.3 Complex care coordination

Multiprofessional, multidisciplinary collaboration is recognized as a central element of integrated care for people with chronic conditions.[12, 87] However, similar to recent findings of a Dutch research group, our study results (described in **Chapters 5 and 6**) highlight the currently unmet needs of patients living

with SSc in Switzerland in terms of care coordination.[10, 11, 20, 55] The PACIC *Follow-up/Coordination* subscale captures the implementation of care that extends and reinforces office-based treatment. This includes making proactive contact with patients to assess progress and coordinate care.[9] For the PACIC-15, the mean score for the shortened (two-item) *Follow-up/Coordination* subscale was relatively high 3.3/5.0 (95% CI: 3.0–3.5). Compared to European rare disease patients, our study's Swiss SSc participants reported receiving considerably more feedback and explanations about specialist visits and examinations ($\bar{x}$=3.6 vs. 2.5).[27] However, the original PACIC-20 items that did not fit our data (i.e., items 17 and 18, see **Chapter 4**) showed very low values: 69% of patients were *never* or *generally not* encouraged to attend community-based programs (item 17: $\bar{x}$=1.9, 95% CI: 1.7–2.1); and 64% were not contacted after visits to see how things were going (item 16: $\bar{x}$=2.1, 95% CI: 1.8–2.4).[10] Confirming these quantitative findings, qualitative interviews revealed that patients often assume responsibility for complex care coordination themselves.

The theme *taking over complex coordination of care* underscored the difficulty patients experience coordinating their own care. Like rare disease patients in other European countries, Swiss SSc patients rarely had contact with their healthcare providers after visits. This is likely explained by the Swiss health system's suboptimal provider reimbursement for outpatient services.[68] Moreover, patients may be receiving care in centres/practices that lack expertise in SSc.[27] One point that underscores the value of post-visit follow-up calls is that study patients treated in centres belonging to a European Reference Network (ERN) reported higher satisfaction regarding 'being contacted after a visit' ($\bar{x}$=2.8 vs. 2.1).

Congruently, our interviewees described *relying on an accessible and trustworthy team* as a central theme relating to finding both professionals and peers for ongoing care and support. Several studies have revealed similar gaps in SSc care delivery (i.e., lack of structured multidisciplinary collaboration, inadequately organized follow-up, poor patient-provider relationships.[20, 55, 74, 88, 89]) Therefore, two key foci of integrated care in SSc are 1. the complex coordination of care regarding timely access to specialized multiprofessional care, and 2. systematic follow-up care that incorporates psychosocial interventions alongside medical follow-up.

Overall, the findings of this thesis underscore and expand on previously identified gaps in the care of patients living with SSc, particularly regarding timely access to specialized multi-professional care and systematic follow-up care.

Implications for clinical practice and policy

At the **micro** level, for patients living with systemic sclerosis (SSc), the broad variability of their disease presentation and symptom burden requires a chronic care approach built on competent, coordinated, multidisciplinary collaboration targeting individual patient needs. This is because both care coordination and follow-up care must start with a joint treatment plan (i.e., one created by HPs from various disciplines together with the patient) that includes individualized goals and interventions targeting the SSc manifestations and consequences that are most important to the patient (see also **section 7.2.2**). As our goal is to produce an integrated care model, the core of that model would be a continuous multidisciplinary team approach that includes non-physician HPs—a group often excluded from consultations.[10]

Such a mix of disciplines aligns well with recent SSc research[25], rare disease recommendations [1] and current information from the Swiss Federal Office of Public Health.[36, 37] And as Denton et al. (2020)[25] demonstrated, in addition to implementing a multi-professional team-based communication approach,

increasing the quality of education for both patients and HPs strongly increases the likelihood of meeting SSc patients' needs and priorities. And to adequately respond to SSc's psychosocial consequences and frequent concomitant mental health disorders, researchers recommend embedding psychologists within these clinical teams.[10, 26] Furthermore, as with other rare diseases, to provide timely access to specialized SSc care, virtual expert consultations must be considered.[1, 90]

Regarding non-pharmacological care in SSc, Willems et al. (2015)[41] emphasize that this disease's wide variations indicate a need to consolidate geographically disparate expertise within countries by developing national care standards. Regarding the co-management of patients and HPs, both HPs and peers can support patients by teaching them to communicate and advocate more effectively for their needs.[39] Patients also need to be trained, for example, to use online tools to assess their health, recognise critical signs and make self-referrals to specialists if needed.

The clear need for systematic follow-up care in SSc warrants the implementation of standard diagnostic and therapeutic pathways, as well as defined collaboration structures for shared care (i.e., agreements about referrals, clear division of tasks, exchange of medical records) between primary care physicians and specialists and/or between HPs working in different hospitals/settings.[18, 43] Primary care physicians play a central role not only in the early diagnosis of SSc, but also in coordinating and follow-up care.[91] As might be expected, early referral to a centre of expertise for SSc is recommended—among other reasons, to ensure close multiprofessional, longitudinal follow-up care.[44, 45] Even after diagnosis, though, it takes 5 years (range 1-12 years) for patients in Switzerland to be treated for SSc at a specialized centre.[44]

In 2019, Hoffmann-Vold et al.[45] reached a consensus with leading SSc experts on strongly recommended and easily applicable tools for a minimum annual systemic assessment of organ involvement using the Delphi method. However, while such assessments are essential, they do not target psychosocial problems.[45] Given their impact on patients' overall quality of life, such problems should also be followed-up at regular intervals.[92, 93] Garaiman et al. (2021)[94] highlighted the need for a regular screening of SSc patients for a referral to a psychiatrist using the Hospital Anxiety and Depression Scale (HADS).

Particularly regarding care provided outside of hospital settings (i.e., primary-, home-, informal care), both case-managers and technological applications would likely facilitate and improve the complex coordination and follow-up care of SSc and other rare diseases.[95, 96] Similar approaches have been successfully employed for more common chronic conditions. For example, diabetes and cancer care teams have long included specialized nurses for counselling, case-management and long-term follow-up. In addition to fostering patient-centredness, their involvement correlates with increases in satisfaction with care and improved clinical outcomes.[38, 97-99]

For example, a 2018 study aiming to improve care coordination of complex cancer patients implemented three strategies: (1) incorporating a nurse practitioner trained in care coordination within a complex care team; (2) implementing an EHR-driven registry to facilitate patient transitions between primary and oncological care; and (3) enhancing teamwork through coaching.[38] While those study's findings are not yet published, two recent studies evaluating coordinator roles have shown that such investigations can improve HRQoL in cancer survivors with low health literacy[100] and care of underserved populations.[101] Important for integrated care, EHR must involve software that supports care planning and tracking of patient data over time and beyond hospital care.[102]

At the **meso** level, local partnerships may foster integrated care across healthcare settings (e.g., between a centre of expertise and primary care physicians).[40] Similar to the micro level, embedding integrated care

within standard practice will require new professional roles that span health and social care. Such roles are already widely implemented in more prevalent rheumatic conditions such as osteoarthritis and rheumatoid arthritis. For these conditions, advanced nurse practitioners' duties routinely include care coordination and/or case-management across healthcare sectors.[6, 103] While such complex tasks require additional training and financial compensation to facilitate exchange of (personal) resources and data, these investments both reduce primary care physicians' management burden and ensure smooth patient transitions between primary and expert centre care.[18, 38] Moreover, the development and implementation of patient self-assessment and -referral technologies needs to be considered at the hospital level.

At the **macro** level, alongside the promotion and funding of initiatives that support multiprofessional collaboration and care across countries and borders, eHealth technologies and certification of centres of expertise are seen as key drivers to improve person-centred service delivery in rare diseases.[104] Until such centres are established, national health systems need to ensure that SSc care is aligned with the *Quality Criteria for Centres of Expertise for Rare Diseases* set by the European Union Committee of Experts on Rare Diseases (EUCERD). While the Committee's criteria include requirements for multidisciplinary and multiprofessional collaboration and coordination,[1, 33] their recommendations focus primarily on the adoption of technology to '*make the expertise travel rather than the patients*'. To this end, they suggest (1) using technology to share expertise (e.g., guidelines, training tool/sessions) and (2) facilitating the exchange of data to improve diagnosis and care.[33]

Barriers to multiprofessional collaboration and care also need to be targeted. Both policies (e.g., regarding data exchange via EHR) and funding mechanisms (e.g., financial incentives) can effectively foster multiprofessional collaboration across a broad range of network structures. These must involve at least three types of connection: (1) horizontal—between national and international expert centres; (2) vertical—across the entire healthcare pathway, from primary care through centres of expertise; and (3) diagonal—across specialties and professions.[33, 37, 42]

While such collaborations promote timely access to specialized care by easing the flow of knowledge, existing concepts of professional roles and norms—or the lack of them—can also impede that flow.[1, 90, 105, 106] For example, in response to wide variations in non-pharmacological SSc care, Willems et al. (2015)[41] recommended developing national care standards as tools to consolidate geographically disparate expertise. Similarly, across high-income countries' health systems, the shift toward person-centred care is understood to require not only multiprofessional collaboration, shared decision making, and a clear distribution of professional roles, but also financing schemes that favour care integration and multiprofessional teams (e.g., payment models that compensate care team members for participation in integrated/interprofessional care models).[36, 37] Especially for rare diseases, defined criteria are essential, among other points, the competencies of HPs working in centres of expertise (e.g., required education, composition of multidisciplinary teams).[18] To achieve the best possible patient outcomes per unit of expenditure, healthcare systems need to change their focus from rigidly separated areas of responsibility to allow a choices of which professions, disciplines, centres and even countries can best support each care pathway.

7.2.4 Monitoring of integrated care programs

As noted above (**Chapters 1 and 3**), assessing and improving eHealth-facilitated integrated care is challenging, as instruments commonly have not yet been developed (in particular outcomes focusing on eHealth technology and effects of eHealth interventions), do not adequately cover current developments

(e.g., social media and internet use) or lack validation.[107-109] In rare diseases, the problem is worse, as not even a common understanding yet exists as to which measurements should be included[1]. Our studies included a non-exhaustive selection of measurements (e.g., HRQoL, PACIC) that may be useful to monitor eHealth-facilitated integrated care and related outcomes.[8, 10, 11] Moreover, patients highlighted the need to define individual disease outcomes, including those defined by patients themselves.[10]

In fact, integrated care programs do not necessarily achieve the intended changes regarding patient experiences (e.g., PREMs) and outcomes (e.g., PROMS)[12] As Hughes et al. (2020)[12] indicated, we should not expect universal answers to narrow questions about whether integrated care 'works'; instead, we should value their heuristic properties. Still, qualitative interview studies have shown that patients and family members tend to be very satisfied with integrated care (e.g., case management), despite being unaware of care models and their aims.[110, 111] In our study (**Chapter 5**), while the patients rated coordination and follow-up care quite highly, they still indicated relevant problems in the following qualitative interviews.[10] Hughes et al. (2020)[12] emphasize that, on the one hand, connections between patient experiences and outcomes tend to be nonlinear, whereas, on the other, relationships with system benefits (e.g., organizational and financial improvements) are more likely to be linear. These arguments support a complexity-driven approach to understanding the dynamics of integrated care programs regarding patient outcomes and experiences.[12]

Insofar as our results (**Chapter 5**) did not confirm an association between PACIC scores and HRQoL in patients with SSc (i.e., SScQoL),[10] they agree with Hughes et al.'s (2020)[12] argument. Mean SScQoL scores were significantly associated with a number of self-reported comorbidities (depression, gastrointestinal problems and osteoarthritis) but not with PACIC scores. Such findings are in line with studies of common chronic conditions, in which PACIC and HRQoL scores correlated only marginally (r= 0.15 and 0.23).[58, 69, 71] They are explained by a previous qualitative investigation's identification of several subjective factors influencing patients' ratings of the care the received (i.e., gratitude, faith, loyalty, luck, equity, engagement with the system).[112]

One interesting exception was patients who had lung problems, who reported higher PACIC levels than those who had none. One plausible explanation is that patients' evaluations of care depend on their level of engagement with the healthcare system, not on HRQoL *per se*. This interpretation suggests that their sense of engagement has a greater influence on HRQoL and patient well-being than the PACIC items, which assess satisfaction/dissatisfaction with the healthcare system.[112]

Another influencing factor when completing PROMs and PREMs in rheumatology is patient literacy. Although most of our study patients (**Chapter 6**) indicated few problems comprehending health-related information on the internet ($\bar{x}$=6.7, 95% CI: 6.2–7.3, range: 1–10), those with less education (i.e., compulsory education only) reported poorer understanding ($\bar{x}$=4.5 vs. 7.1; SMD = 0.81). Similarly, several studies revealed that many rheumatology patients completing PROMs do not understand what they are answering, leaving them unable to provide an accurate perspective on their condition.[113, 114] Similarly, in systemic lupus erythematosus (SLE), a recent study found significantly worse patient-reported outcome scores among individuals with limited health literacy.[114] However, determining whether these disparities reflect actual differences in health or measurement issues will require further investigation.[114]

Moreover, improving outcomes via eHealth-facilitated integrated care will require targeting end-users' concerns. Experts participating in our focus group discussions (**Chapter 6**) emphasized patients' and

HPs' concerns regarding eHealth use. These included not only the lack of human, financial and time resources, but also the danger that ICT use would replace interpersonal interactions and relationships.[11] The patients were especially concerned about data security and becoming dependent on ICTs. Within this context, one long-term aim of monitoring PROMs, PREMs and concurrent (e.g., qualitative) evaluations should be to engage end users to participate in eHealth programs' development processes, then to support those programs' implementation. By allowing developers to correct their current perspectives, this will both support their programs' utility and foster uptake of effective interventions.[54, 115]

Overall, these results highlight the micro-, meso- and macro- level difficulties and needs associated with monitoring eHealth-facilitated integrated care in SSc. As illustrated by Leijten et al. (2018),[48] monitoring integrated care is necessary to allow care continuity (see also **section 7.2.3**) and research (see also **section 7.4**), both of which share three major aims regarding the target population: (1) improve patients' health; (2) improve patients' experiences; and (3) reduce costs.[48, 116]

Implications for clinical practice and policy

At the **micro** level, individual patients' PROMs and PREMs should be used in ways that maximize their value regarding care outcomes—especially those that depend upon continuity of care.[48] This may include sharing hospital discharge- and medication-related information with primary care providers and pharmacists, as this allows coordination between multiple providers to accommodate both patient and provider preferences.[47, 48] Additionally, PROMs can be used for individual risk prediction and proactive care. Specifically for SSc with its many possible symptoms and psychosocial consequences, screening tests may be useful to focus on nascent health issues (e.g., psychosocial and physical symptom burden) while developing the patients' (e)health literacy.[50] Symptom tracking technology or a Patient Journey Record System may help to proactively coordinate care.[48, 49] The latter of these allows early detection of adverse changes in patient biopsychosocial trajectories and prompts tailored care.[49]

Importantly, patient-defined goals and outcomes provide a holistic view of patients' main issues and the therapeutic options that will best facilitate comprehensive management of their conditions.[51, 117] Patient-defined treatment goals and patient definitions of treatment success may change over the disease's trajectory.[118] Similarly, our study (**Chapter 6**) revealed that when using PROMs and PREMs for regular disease monitoring (e.g., disease registries, symptom tracking), patients understand that a clinician will check what they have assessed and discuss their measurement outcomes with them during a consultation.[11] As a result, in addition to supplying data necessary to tailor and match care options to their needs, PROMs give SSc reassure patients that they are being looked after even between clinic visits.[48]

At a **meso** level, to define the monitoring of integrated care programs, patients and other stakeholders (i.e., end-users) must be involved from an early stage of program development, using a holistic approach to co-design.[52, 53] Congruently, our study's focus group HPs agreed that eHealth services need to be well planned and adjusted to match not only existing clinical procedures, but also hospitals' staffing and financial situations.[11] To achieve the best possible matches, end-users' worries need to be taken into account, not only by engaging them as stakeholders in the development process and using health outcomes to measure program efficacy, but also by focusing on health care processes and their utilization (i.e., dissemination and implementation research).[11, 54]

Accordingly, in a recent Dutch study, patients with SSc prioritized process and outcome indicators to evaluate quality of care as follows:[55] The three highest-priority process indicators were (1) a trusting, communicative patient-physician relationship; (2) well-structured multidisciplinary collaboration; and (3) delivery of treatment according to SSc guidelines. Their top-priority outcome quality indicators were the absence of (1) disease progression; (2) organ involvement; and (3) digital ulcers.[55] Across the meso level in general, there is a need to develop process quality indicators that relate specifically to people with rare diseases and their associated comorbidities, so that their special needs can be targeted regarding care continuity and integration.[1, 27, 48]

At the **macro** level, for a population as small as that of SSc patients, systematic disease-specific assessment and evaluation of PROMs and PREMs demands international/multicenter collaboration to recognise relevant care patterns, make overarching statements and improve care.[1, 48] In "Recommendations from the Rare 2030 foresight study," Kole et al. (2021) highlight the principle that maximizing data collection and sharing (e.g., inter-organizationally, internationally) will maximize improvements in the health and well-being of people living with rare diseases.[1] Indeed, much SSc research relies on registries (e.g., the European Scleroderma Trials And Research (EUSTAR)) and research networks (e.g., the European Reference Network on Rare and Complex Connective Tissue and Musculoskeletal Diseases (ERN ReCONNET) and SPIN), to achieve adequate sample sizes and increase their generalizability.[56, 57, 83] This requires not only effective privacy and data protection legislation, but also healthcare policies that stimulate research on integrated care in rare diseases.[1, 48] Perhaps most importantly, healthcare systems need to respect patient preferences and invest adequately in education and training on data collection and utilization across disciplines and borders.[1]

At the international level, a recent study conducted in eight European countries compared patients' and other stakeholders' (n=5122) preferences for outcomes of integrated multimorbidity care.[53] Of the five stakeholder groups (i.e., patients with multimorbidity, their partners and other informal caregivers, health professionals, payers and policymakers), the preferences of professionals differed most often from those of patients. Such differences highlight the importance of shared decision-making (see **section 7.2.1**). Across all countries, patients and most other stakeholders assigned the highest preference to the well-being outcome 'enjoyment of life'. Furthermore, patients assigned the highest weights to outcomes relating to physical functioning, psychological well-being and continuity of care. Similarly, continuity of care was ranked among the top three outcomes of professionals, payers and policymakers of four countries. Payers and policymakers assigned higher weights than patients to costs, but these weights were relatively low.[53]

7.3 Strengths and limitations of methods used

One of this thesis's primary aims was to describe current chronic illness care (**chapter 5**), eHealth literacy (**chapter 6**) and care needs from patients' and providers' perspectives, and to use the data as a base upon which to develop our proposed SSc care model. The contextual analysis described in these studies was guided by Gee et al.'s eCCM,[3] a widely used and effective chronic care model that incorporates electronic media.[5] The combination of this framework and a mixed methods approach broadened our perspective on integrated care needs in SSc.

We used an explanatory sequential mixed methods design, and involved multiple centres providing SSc care as well as the SSc patients' association to recruit patients and HPs.[7] First, we conducted a cross-sectional survey of Swiss SSc patients (n=101) and healthcare professionals (n=47). Quantitative analyses

of the gathered data informed subsequent qualitative interviews with patients (n=14), professionals (n=14) and family members (n=5). Another important step was to discuss our quantitative results within three focus groups including Swiss/international patients and professionals (n=17). Our aim was to inform the development of an integrated model of care for SSc.

The strengths of this mixed methods approach became visible when comparing the quantitative and qualitative data. First, the quantitative findings (particularly regarding the PACIC and eHealth literacy scales) were complemented by qualitative data from interviews. These qualitative data broadened our understanding of the quantitative findings, and provided insight into patient and HP experiences that quantitative research alone would not have captured. Second, the focus group interviews allowed us to discuss and validate our results within a range of stakeholders who were geographically diverse (i.e., from Switzerland, various European countries and the USA), and came from professional backgrounds including health policy, medicine, nursing and/or biomedical research. Regarding some points the individual and/or focus group participants confirmed or deepened our understanding. For others they showed that, despite the value of our quantitative results (e.g., for the PACIC *Follow-up/Coordination* subscale score), we had made relevant errors regarding the patient's point of view. In addition, qualitative data explained the variability of our quantitative data and the misfits of certain individual PACIC questionnaire items (**Chapter 5**). This provided a clear illustration of why patient-defined individual outcomes may be important, as long as existing instruments do not adequately capture complex care coordination in rare diseases as SSc.

Despite the insights this research project provided, it had three main limitations. First, we were challenged to identify relevant and validated instruments for our contextual analysis. When designing the project, we recognized that selected measurements would require language/cultural adaptations and further validation.[10, 119] Therefore, rather than delay the MANOSS project, we waited until after it was established to plan the validation of the German version of the SScQoL questionnaire; and therefore we did not allow either for multiple measurement points or for multinational validation.[8]

A second limitation is that the cross-sectional survey and individual patient interviews were conducted only in the Swiss setting, making it difficult to generalize our results internationally. The international focus group largely supported our findings; however, as this only included one patient, caution is warranted in generalizing findings beyond the Swiss setting. Furthermore, we did not include primary care physicians and non-rheumatology specialists (i.e., cardiologists, pneumologists) in the focus groups, thereby limiting inferences regarding multi-professional management.

Third, as the design of our cross-sectional survey did not allow comparisons between centres, it is not possible to assess which care team/model worked best.[7] This would have been interesting not only to inform the implementation of chronic care strategies, but also to recommend centre-specific improvement strategies. Also, a EURORDIS survey noted that patients reported better chronic care experiences when treated in European Reference Network (ERN) centres. This highlights the value of access to expert care for rare diseases.[27] Regarding SSc, Robson et al. (2020)[26] attributed disparities in access to specialist psychological support across the United Kingdom partly to location/treatment facility type (i.e., district general hospital, teaching hospital, National Health Service (NHS) specialist centre) and partly to the treating physician's speciality (i.e., nephrology, rheumatology).[26]

7.4 Implications for future research

Based on the findings reported above, we see a strong need to implement eHealth-facilitated integrative care programs in SSc. Our contextual analysis can serve as a national and international road map for future integrated care program development and research. Thus far, our results have shown a clear need for SSc care teams not only to improve their sharing of informed decision-making with their patients and their families, but also to align their coordination and follow-up of care with European quality recommendations for rare diseases. These include requirements for multidisciplinary and multiprofessional collaboration and coordination.[1, 33] Moreover, our findings identify gaps in psychological and self-management support for people with SSc.

As the next step of our MANagement Of Systemic Sclerosis (*MANOSS*) study protocol for the development of a rare disease chronic care model for patients living with SSc in Switzerland and their families,[7] we plan to analyse and publish the remaining quantitative data (i.e., HP survey on chronic care) and qualitative data from individual interviews with patients (n=10), family members (n=14) and HPs (n=5). To qualitatively describe the SSc patient perspective of chronic care, we used a 4-patient subsample purposefully selected from the quantitative MANOSS study sample based on their PACIC and SScQoL scores.[10] Thus, although we have conducted and transcribed the qualitative interviews of all three stakeholder groups, further work is needed to adequately integrate the resulting data into the development of our model. These data will be particularly valuable both to integrate the psychosocial needs of persons with SSc and their families, but also to understand the organizational aspects of SSc management from the HPs' perspective.

Second, we will incorporate the overall findings of the MANOSS project into the first draft of a logic model, which will describe how we anticipate our proposed integrated care activities and implementation strategies will lead to the desired outcomes.[120] To maintain a strong end-user focus, this process will be accompanied by further focus group discussions, this time including micro-, meso- and macro-level stakeholders. After our experience with the international focus group, which contributed greatly to putting our Swiss results into an international context, we realised that such group discussions can better support us during the final model development phase than the originally planned Delphi approach.[7] Additional investigation may focus on our SSc patients' active roles in designing/co-creating this eHealth-enhanced care solution.[11, 19]

Given the broad evidence regarding SSc patients' integrated care needs in Switzerland, we should be able to progress quickly from descriptive to intervention and implementation studies to developing and testing new eCCM-guided care approaches.[3] Studying more frequent chronic conditions, researchers have observed positive results on outcomes and processes of care—and to a lesser extent, quality of life— when implementing even a single element of the eCCM.[5] This highlights the power of testing multicomponent care programs that contain such elements (e.g., care coordination and self-management support). With this in mind, future research should focus on identifying effective components of SSc integrated care.

For example, we already see a strong potential for implementing specialized case managers (e.g., nurse practitioners),[6, 103] a national SSc self-management program (e.g., a translated/adapted version of an existing program)[29, 82, 84] and one-to-one peer support.[18, 34] In people with SSc and their families, both self-management and peer support can be used to improve (e)health literacy, care experiences, management of symptoms, daily tasks and illness-related emotions, as well as HRQoL and general well-being. For the validation of the SScQoL, though, further studies should include patients from Austria,

Germany and Liechtenstein to confirm the robustness of the German SScQoL and ensure its transferability. Additionally, future work may include calibration and cross-cultural comparability studies using data from other European countries.

Regarding not only Switzerland's SSc population, but also internationally and broader rare disease populations, it would be very useful to investigate and monitor disparities in integrated care between centres and countries.[1, 26] Despite the clinical heterogeneity of rare diseases, individuals with different manifestations may experience similar difficulties, such as lack of access to reliable information and specialized healthcare.[1, 121]

While rare disease populations have been called internet "power users," no tools specifically address their specific methods of finding online sources, learning about their conditions, or even crowdsourcing solutions.[122] Future research may focus on eHealth literacy in broader rare disease populations to determine which SSc-related findings are SSc-specific and which are representative of experiences of rare disease patients more broadly. Moreover, PREMs for rare diseases (e.g., the PACIC questionnaire) require further validation in rare disease populations to become sensitive enough to reliably indicate, for example, a patient's sense of engagement with the healthcare system.[10, 112]

Overall, multinational and multicentre projects will be necessary to overcome research-related challenges in rare diseases, particularly their rarity.[123] Future development and testing of programs could include collaborations with the European Reference Network on Rare and Complex Connective Tissue and Musculoskeletal Diseases (ERN ReCONNET) to increase their generalizability.[57] Importantly, mixed methods (i.e., triangulating quantitative and qualitative data) and implementation science designs can help to address limited statistical power when testing such programs in rare disease populations.[54, 124] Last, stakeholders need to ensure that incentives for rare disease research are in place not only for basic research but also for implementation science projects.[1]

7.5 Conclusion

This dissertation project adds to the evidence regarding care needs of patients with SSc and their families by exploring chronic illness management practice patterns and laying a foundation for the development of an eHealth-facilitated integrated model of SSc care. Using the eCCM for our framework, along with a mixed methods approach successfully clarified our perspective on SSc care needs and key elements of chronic care not yet systematically implemented in the management of this rare disease.

Accordingly, our research turned up four target areas for system change, all of which will play important roles in the reorganization of care toward a person-centred rather than the current organization-centred model: 1. shared and informed decision-making; 2. complex care coordination; 3. self-management and psychological support; and 4. monitoring of integrated care programs. Our experience with of these can be used to inform future model development. We will target them at the clinical (micro), delivery system (meso), and the health system (macro) levels. We consider developing and testing multicomponent care programs that contain at least one eCCM element (e.g., care coordination and self-management support) extremely valuable for future improvements. Not only the introduction of new modes of care delivery, but also the consolidation of expertise within and between countries will vastly improve both continuity of care and access to that care.

Beyond research, our results have identified significant educational needs in patients and HPs, especially sharing both decision-making and responsibility for (self-)managing the disease and using eHealth, as

well as using ICTs to facilitate patient-centred care. When implementing such approaches and technologies in the service of integrated care, our findings strongly emphasize the need for targeted training—not only of patients but also of HPs. Even otherwise experienced clinicians commonly lack competence not only using eHealth resources, but also co-managing the disease alongside patients. Therefore, integrated care programs need to focus on individualized goal-setting and treatment planning together both with the patient and within the multiprofessional team. To make the necessary changes, future projects to re-design care will need to target two key aspects of patients' and HPs' skills: 1. sharing care and related decisions; and 2. using eHealth as a mode of delivery.

Next, we fully expect that our project findings will contribute to a clearer understanding of how to use PROMs and PREMs in SSc, as these are increasingly used to evaluate care and new care approaches. Well-implemented PROMs and PREMs can also build care providers' understanding of each patient's specific concerns. Through the successful revision and validation of the SScQoL for German speaking contexts, we will provide a valid SSc-specific HRQoL measure that can be used with confidence in clinical settings. Likewise, with the first use of the PACIC questionnaire in patients with SSc, we recognized its potential to improve integrated care in this rare disease population. However, our German-language versions of both the SScQoL and the PACIC will require further adaptation and/or cross-cultural validation to systematically evaluate, for example, patients' sense of engagement with their healthcare systems, or disparities in integrated care between centres and countries. Moreover, a comprehensive assessment of eHealth-facilitated integrated care in SSc will require a wide range of additional measurements.

Finally, this dissertation project's comprehensive contextual analysis highlights the value of involving patients and other stakeholders in the development of a rare disease care model. Perhaps most importantly, our report of our experience with the eCCM framework and methodology can be used as a guide to employ the same tools to other rare disease populations' integrated care needs. We encourage other researchers to develop both targeted programs and improved outcome measurements for eHealth-facilitated integrated care. Ultimately, this will not only support patients to self-manage their condition, but also encourage healthcare providers, managers and policymakers to adopt and embrace person-centred healthcare delivery.

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