Introduction

Across the developed world, the primary cause of patient morbidity comes from chronic conditions such as cardiovascular disease, cancer, stroke, diabetes, arthritis, and mental illness.1 Global increases in the prevalence of chronic disease have placed greater demands on traditional healthcare systems, which are typically optimized for the delivery of acute care. The Chronic Care Model advocates that chronic disease management (CDM) can be improved if health services reorganize to prioritize support for patient self-management, user-friendly delivery systems, clinical decision support, and coordination of clinical information within and between healthcare organizations.2

Chronic disease can be understood as a significant life stressor, which results in functional impairments and reduced quality of life. Adapting to chronic disease has been understood as a lifelong psychosocial challenge, with ongoing psychological stressors associated with recurring symptoms, unpredictable disease course, and exhaustion due to disease progression.3 Given these challenges, it is hardly surprising that chronic physical disease is often associated with elevated rates of depression, anxiety, and stress.4 High-quality adaptation to chronic disease requires that patients have access to information about disease management, can engage proactively in monitoring and managing symptoms, and are able to accommodate the demands and functional impairments of chronic disease, by accessing support networks.5,6

Research has documented a higher prevalence and burden of chronic disease in rural areas,7,8 perhaps due to rural–urban disparities in both the exposure to risk factors for chronic disease, and in access to relevant healthcare services and CDM resources.6,9 Research has also shown that rural people experience stigma associated with health issues, and that this can delay help-seeking,10 reduce adherence to medical treatment plans,11 and result in a preference for anonymous sources of health information.12 In addition, patients in rural areas often experience higher levels of social isolation, which can hamper access to the social supports needed to adapt to the demands of chronic disease.5,6 Recognition of these disparities has come alongside increasing penetration of the Internet and greater access to computers and the Internet in rural areas across many countries.13 This has prompted interest in the implementation of web- or mobile-based telehealth interventions, particularly in countries with dispersed populations and established telecommunications infrastructure.14 Telehealth has been defined as “the use
of technology to support the remote delivery of healthcare and promote self-management. Examples of telehealth applications include video-conferenced consultations, store and forward systems, telemonitoring applications, and electronic health records systems, most of which are typically mediated by healthcare providers. In addition, stand-alone web-based interventions to support CDM have proliferated in the early twenty-first century. Such interventions are proposed to assist patients in adapting to the demands of chronic disease. Recent systematic reviews have documented mixed results, but overall suggest that web-based CDM interventions are effective, with improvements in health-related knowledge, increased treatment adherence, and reductions in psychosocial and symptom-related distress.

While there is evidence supporting the effectiveness of web-based CDM interventions, research has also described practical difficulties in implementing such interventions among rural populations with chronic disease. There is a well-documented disparity in Internet access for people in rural areas compared to those in urban areas, termed by some a digital divide. Even where Internet access is readily available, concerns have been raised as to the acceptability of web-based CDM interventions among patients with chronic disease. The Technology Acceptance Model proposes that the perceived usefulness and usability of a technology will predict its acceptance. However, more recent theories aiming to explain the integration of new technology into healthcare service delivery have also described a complex socio-technical challenge, which requires understanding of the social worlds into which such interventions are introduced.

Hardiker and Grant described a conceptual framework of categories that influence user perceptions of, and engagement with, web-based health interventions. These include user characteristics, technological aspects, service characteristics, social aspects of use, and telehealth services in use. Since the late 1990s, there has been a rapid increase in the number of publications relating to the acceptability and feasibility of web-based interventions. Or and Karsh reviewed studies examining acceptance of computer-based health information and found that younger, better-educated, and more affluent respondents showed greater enthusiasm for these sources of information. However, these sociodemographic characteristics are inversely related to chronic disease prevalence. Despite this developing literature, there is still a relative lack of studies focusing specifically on those with existing chronic disease, or those living in rural areas. As rural–urban inequities are often used to justify the need for developing and evaluating web-based delivery of CDM interventions, it is important to review the existing literature, specifically examining the effectiveness and uptake of such interventions among rural populations with chronic disease. This review aims to:

- Evaluate the evidence for the effectiveness of web-based CDM interventions among rural populations with existing chronic disease, and
- Describe and synthesize current findings regarding optimal methods of implementing web-based CDM interventions in rural settings.

**Methods**

**Methodological framework.** Data were analyzed and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.

**Data sources.** A literature search was conducted in May 2015. Peer-reviewed articles, conference proceedings, and gray literature were searched, using the following search engines and online databases: Web of Science, PubMed, PsycInfo, Academic Search Premier, Health Source (Nursing/Academic Edition), Ovid EBM Reviews, Ovid Embase, Ovid Global Health, AustHealth, and Science Direct. The search strategy was built using the following Medical Subject Heading terms: “Self Care” OR “Chronic Disease” OR “Patient Education” AND “Rural” OR “Remote” AND “Internet” OR “Online”, appearing in Title/Abstract and/or Summary fields (depending on options provided by individual databases).

Initial searches of online databases found 497 records. One additional record was found by searching reference lists of relevant articles, and by accessing systematic reviews of web-based interventions for CDM in broader settings (ie, not specifically rural settings). Figure 1 shows the process of record screening.

**Figure 1.** Schematic diagram of record screening process.
Acceptance of online CDM interventions in rural and remote settings

of removing duplicate records, screening titles and abstracts for relevance, and screening full text for relevance, along with the records removed at each stage.

**Study selection.** Full-text articles were screened against the following criteria for inclusion in the review:

1. Article published in English, in a peer-reviewed journal, between 1995 and 2015.
2. Reported on a specific intervention, in which web-based materials or web-based delivery was a key component.
3. Interventions were targeted at patients with existing chronic physical disease.
4. Interventions addressed one or more dimensions of the Chronic Care Model (self-management support, delivery system design, decision support, clinical information systems, community resources, policies, and healthcare organization).3
5. Data were collected in a rural (non-metropolitan and non-urban) location, or the data were stratified by rural-ity for reporting.
6. One or more of the following patient-level processes or outcome measures were collected: adherence to intervention (eg, number of logs or time spent engaging with resources), health-related knowledge, self-management of chronic disease (ie, adherence to CDM plan or self-efficacy in CDM), psychosocial functioning (ie, depression, quality of life, symptom-related distress, or social support), and/or physiological indices of CDM (eg, blood glucose levels).

For the purpose of this review, chronic physical disease was defined as those illnesses or health conditions that have a biological underpinning, prolonged course of illness, result in functional impairment, or disability, typically do not resolve spontaneously and cannot be completely cured.34,35 While interventions targeting patients with comorbid chronic physical disease and mental illness were included, those focusing solely on web-based psychotherapy for patients with mental illness were excluded. CDM may be improved by lifestyle interventions (eg, reduced alcohol intake); studies of such interventions were included if they were implemented among patients with existing chronic disease; however, population-based interventions were excluded. As this review aimed to evaluate optimal methods of implementing web-based CDM interventions in rural settings, small-scale pilots and feasibility trials assessing intervention uptake were also included, even if they were underpowered to adequately assess patient-level CDM outcomes.

**Review process.** Following full-text screening of the identified references, 15 articles (13 unique studies) were included in the review. Figure 1 shows the number of papers screened at each stage. One multiphase randomized controlled trial was the subject of five papers (three unique studies) included in the review.5,36–39 Two full-text articles were not retrievable and were not used in the review. Study authors were not contacted with requests to provide additional data.

**Data extraction.** Data extraction was undertaken for all full-text articles included in the review, using predefined fields specified in Table 1.

**Data synthesis.** Owing to significant variability in study design, disease groups targeted, contextual variables (eg, local telecommunications infrastructure), interventions delivered, and outcomes measured, a narrative synthesis was conducted, rather than a meta-analysis. Multiple papers describing the same overarching study were grouped for the purpose of synthesis and reporting. The heterogeneity of study designs and methods in the reviewed papers made a conventional risk of bias assessment problematic. Studies were instead classified descriptively into A (randomized controlled trial), B (nonrandomized controlled trial), or C (uncontrolled trial) to assist in data synthesis. Pilot trials or feasibility studies focusing primarily on process outcomes (eg, descriptive analysis of barriers or measures of intervention uptake) were included and classified as D level evidence.

**Results**

**Overview of reviewed studies.** Of the 13 studies reviewed, three were categorized as web-based self-management interventions,40–42 six were categorized as interactive online groups,5,36–39,44–46 and four were categorized as provider-mediated online interventions.47–49 The duration of the interventions ranged from single sessions to years, with the majority lasting ∼10–12 weeks. Three studies used a randomized controlled trial design, two were nonrandomized controlled trials, and five were uncontrolled trials. Three studies focused on process measures or qualitative feedback relating to implementation and were categorized as feasibility studies. Seven studies recruited only patients from a specific chronic disease group (diabetes = 4, cancer = 1, pediatric asthma = 2), and six studies recruited patients with a broad range of chronic diseases. Three studies specifically recruited women with chronic disease,5,36–39 and three studies specifically recruited children.43,47,49 Seven studies were conducted in the United States, two in Canada, two in Australia, one in Korea, and one study focused on remote American military stations across several Western Pacific locations. Of the studies conducted in United States, Canada, and Australia, participants were predominantly of Caucasian ethnic backgrounds.

**Patient outcomes.** Ten of the reviewed studies measured patient outcomes that were directly relevant to CDM, including health-related knowledge, self-reported attitudes or confidence in CDM, health-related behaviors, psychosocial wellbeing, or physiological indices of CDM. No studies assessed long-term outcomes such as mortality or disease-related morbidity. Eight of the 10 studies that assessed patient outcomes reported attrition rates across the course of the intervention. These 10 studies are grouped into intervention modality and described below.
<table>
<thead>
<tr>
<th>STUDY</th>
<th>DESIGN, CLASSIFICATION</th>
<th>POPULATION, LOCATION, SAMPLE</th>
<th>CONDITIONS, MEASURES</th>
<th>PATIENT OUTCOMES</th>
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</table>
| **Web-based self-management interventions**

| Jemigan et al (2011). | Online diabetes CDM feasibility trial | Feasibility study (D) | Patients with diabetes | L: United States | S: N = 54 (27 American Indian/Alaskan native peoples, 60% of these lived on/near reservation) | T: Online CDSMP (N = 27) optimized for American Indian/Alaskan native peoples | C: Comparator group (N = 27) of predominantly Caucasian background (same treatment) | Duration: 6 wk | M: Qualitative, descriptive (focus groups), program usage statistics | T: Similar engagement in action planning compared to C. T group more likely to use online CDSMP during daytime hours (internet accessibility in work settings). Group discussion indicated cultural acceptability, but barriers included time demands and access difficulty (for some) |
| Mcilhenny et al (2011). | MyHERO | Non-randomized controlled trial, (B) | Rural patients with diabetes | L: Rural United States | S: N = 98 (48 female, 100% rural) | T: Nurse-supported use of online health information (MyHERO) (N = 48) | C: Pamphlet promoting use of MyHERO (N = 50) | Duration: 6-mth | M: Health knowledge, SR QoL, SR health behaviors, MyHERO satisfaction rating (T only), physical health (blood glucose, HbA1C, lipids) (baseline, 3-mth, 6-mth) | Attrition: T: 27%, C: 62% | Significant increase in disease knowledge and SR health behavior for T over C at 6-mth follow up. Reduced blood glucose for T compared to C at 6-mth follow up. T group satisfied with nurse support but not online intervention. |
| Wyatt et al (2008). | ‘Okay with asthma’ | Uncontrolled trial, (C) | Rural school children (8–11 yr with asthma) | L: Rural United States | S: N = 35 (16 female) | T: Online CDSMP (N = 35) | C: N/A | Duration: Single after-school session | M: Health knowledge, SR attitudes toward illness | Attrition: N = 37 completed baseline, but N = 2 lost to follow-up | Significant improvements in health knowledge and SR attitudes toward illness at 2 wk follow up, compared to baseline |
| **Interactive online groups**

<p>| Guilcher et al (2013). | Telehealth delivery of Stanford CDSMP | Feasibility study (D) | N = 253 rural patients with CD (lung, heart, stroke or arthritis) | L: Rural Canada | S: N = 44 (30 female) | T: Weekly, video-conferenced, facilitated, 2.5 hr tele-CDSMP support groups | C: N/A | Duration: 6 wk | M: Qualitative, descriptive (focus groups) | Tele-CDSMP provided greater access to healthcare. Technical problems impacted on effectiveness, need for strong facilitator to guide group. Preference for longer sessions. |
| Long et al (2013). | SA Health Chronic Disease Management Trial | Uncontrolled trial, (C) | Patients with CD (not disease specific) | L: South Australia | S: N = 254 (174 female, ~50% rural, 98% Caucasian) | T: Interactive bulletin board + online CDSM resources (N = 254) | C: N/A | Duration: 6 wk | M: SR health ratings, SR health behaviors and SR healthcare utilization (baseline, 6-mth, 12-mth) | Attrition: 16% (6-mth 15% (12-mth) | Significant improvement in SR health ratings, SR health behaviors, SR health utilization at 6-mth follow up, maintained at 12-mth follow up. No difference in results by rurality |
| Stephen et al (2012). | ‘Cancer Chat Canada’ | Uncontrolled trial, (C) | N = 351 cancer patients or carers in ‘Cancer Chat Canada’ | L: Canada | S: N = 102 (26 from rural survivor’s group) | T: Online, synchronous, support group (N = 351) | C: N/A | Duration: 10–12 wk | M: Qualitative, descriptive evaluation (post-intervention satisfaction interviews) | Attrition: 26% | Following adaptation to communicating online via text, participants reported psychosocial benefits associated with sharing experiences and learning how others coped. Convenience of accessing support from home was beneficial |
| Weinert et al (2005). | ‘Women-to-Women’ Phase 2 (Preliminary data) | Feasibility study (D) | Rural, middle-aged women with CD (not disease specific) | L: United States | S: N = 63 (100% female, 97% Caucasian) | Treatment conditions and duration as below (‘Women-to-Women’ Phase 2) | M: SR computer skills (baseline, 9-mth) | SR computer comfort (T1 vs C at 9-mth), SR Internet use (T1 vs C at 9-mth) | Attrition: not reported | Significant increase in SR computer skills for T1 over C at 9-mth follow up. Those in T1 had higher SR computer comfort and SR Internet use than those in C at 9-mth |</p>
<table>
<thead>
<tr>
<th>Study</th>
<th>Title</th>
<th>Design</th>
<th>Population</th>
<th>Intervention</th>
<th>Outcome Measures</th>
<th>Attrition</th>
<th>Summary</th>
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<tr>
<td>Weinert et al (2011). 'Women-to-Women' Phase 3</td>
<td>RCT, (A)</td>
<td>P: Rural, middle-aged women with CD (not disease specific) L: Rural United States S: N = 309 (100% female, 91% Caucasian)</td>
<td>T: Online, asynchronous, support group + fortnightly CDSM health education units (N = 155) C: No treatment (N = 154) Duration: 11 wk M: SR psychosocial adaptation and SR distress (baseline, post, 6-mth)</td>
<td>Attrition: T:24%, C:14% Significant increase in psychosocial adaptation (self-esteem, acceptance) and reduced distress (depression, stress, loneliness) for T over C at 6-mth follow up</td>
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Provider-mediated online interventions

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<tr>
<th>Study</th>
<th>Title</th>
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<tbody>
<tr>
<td>Cho et al (2011).</td>
<td>Telemonitoring by PDA glucometer</td>
<td>Non-randomized controlled trial (B) with retrospective data collection</td>
<td>P: Rural patients with type 2 diabetes L: Korea S: N = 71 (43 female)</td>
<td>T: Remote teleconsultation and glucose control feed-back to rural nurse by diabetes specialist + personalized CDM education (N = 36) C: Non-personalized CDM education (N = 35) Duration: 12 wk M: HbA1c, number of self-monitored blood glucose tests</td>
<td>Attrition: T:11%, C:9% Significant reduction in HbA1c and lipids for T compared to C at 12 wk follow up. Significant increase in blood-glucose self-monitoring for T compared to C</td>
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<td>Corriveau et al (2008). 'Carelink' Insulin Monitoring</td>
<td>Non-randomized controlled trial (B) with retrospective data collection</td>
<td>P: Children with type 1 diabetes mellitus L: USA S: N = 94 (55% female, 37% rural)</td>
<td>T: Remote teleconsultation, glucose control and insulin dose feedback by endocrinologist (N = 41) C: No-access comparator group (N = 33) and 'non-user' comparator group who had access (N = 20) Duration: 1 yr pre-Carelink, 2 yr post-Carelink M: HbA1c, frequency self-monitoring, number uploads per month, number clinic visits per year</td>
<td>Attrition: N/A, all data available. Among rural patients, significant reduction in HbA1c for T (pre vs post) with no such change in C groups. Not significant for urban patients. No difference in uploads but 'non-user' C group had less self-monitoring than 'no-access' C or T</td>
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<td>Malone et al (2004). 'Electronic Children's Hospital of the Pacific'</td>
<td>Uncontrolled trial, (C)</td>
<td>P: Remote pediatric asthma patients L: Western Pacific island military stations (Guam, Okinawa, Korea, Japan) S: N = 33 referred, N = 7 complete 12-mth follow up</td>
<td>T: Remote teleconsultation and CDM recommendation to primary care provider by pediatric pulmonologist C: N/A Duration: 12-mth M: Symptom severity, ED visits, unplanned clinic attendances, SR medication adherence, MDI technique.</td>
<td>Attrition: uncertain (project ended prior to all patients having 12-mth follow up). Significant reduction in symptom severity, ED visits and unplanned clinic attendance pre vs post. No significant difference in patient adherence to medication or MDI technique</td>
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<td>Schrader et al (2014). Web-based Flinders CDM tools</td>
<td>Uncontrolled trial, (C)</td>
<td>P: Rural patients with CD (not disease specific) &amp; comorbid mental illness L: Rural South Australia S: N = 8 (5 female)</td>
<td>T: Online Flinders CDM (N = 8) C: N/A Duration: 6-mth M: SR health ratings (baseline, post)</td>
<td>Attrition: 25% did not 'log in'. No significant improvements in SR health ratings. Majority of logins occurred early in the week, coinciding with automated reminder messages. Technical difficulties and lack of computer skills hampered engagement</td>
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**Abbreviations:** P, Population; L, Location; S, Sample; T, Treatment condition; C, Comparator condition; M, Measures; CD, Chronic Disease; CDM, Chronic disease management; CDSM, Chronic disease self management; MDI, Metered dose inhaler; N/A, Not applicable; QoL, Quality of Life; RCT, Randomized controlled trial; SR, Self report; mth, month/s; wk, week/s.
Web-based self-management resources. McIlhenny et al recruited 98 rural patients with diabetes into a trial of an online portal (MyHERO) to facilitate access to health information relevant to CDM. The intervention group received instructional materials promoting the resource, along with ongoing support from a nurse educator in utilizing the resource over a six-month period. The control group (patients at another clinic) received just written instructional materials promoting the online resource. At the end of the intervention, patients in the intervention group showed reduced blood glucose levels, increased health-related knowledge, and increased self-reported health behaviors, compared to the control group. There were no significant changes in vital signs (eg, blood pressure, heart rate) or other clinical indicators. Owing to the ongoing interaction with the nurse educator in the intervention group, it is difficult to assess the extent to which these significant differences are specifically associated with the online resource. Patients were satisfied with the nurse support, but reported less satisfaction with the MyHERO resource.

Wyatt and Hauenstein conducted an uncontrolled trial of a single-session online intervention, aimed at improving CDM among rural school children with asthma. Thirty-five students completed the intervention and follow-up assessments under the supervision of a registered nurse, with significant improvements in health-related knowledge and self-reported attitudes toward illness at two-week follow-up.

Interactive online groups. Lorig et al conducted an uncontrolled trial of a six-week online self-management program, combined with an asynchronous, interactive bulletin-board, for groups of 16–25 participants with a range of chronic conditions. Bulletin-board posts were moderated by two peers, people managing chronic disease who were trained in chronic disease self-management (CDSM) and workshop facilitation techniques. Patient outcomes were assessed at baseline, six-month, and 12-month follow-up. The intervention was guided by self-efficacy theory, with participants encouraged to self-tailor the available (non-disease-specific) self-management resources to their personal needs. This study found significant improvements on a range of self-reported health ratings (increased global health, reduced illness intrusiveness on role function, reduced health distress), health behaviors (increased exercise duration, reduced alcohol consumption, and increased self-efficacy to manage condition), and healthcare utilization (reduced emergency department visits) at both 6- and 12-month follow-up, compared to a baseline measure. Fifty percent of participants lived in rural areas, and patient outcomes were not significantly different based on rurality.

Stephen et al reported on Cancer Chat Canada, a 10–12-week, online, health professional-facilitated, text-based, synchronous support group, for Canadian cancer patients. Facilitators had a minimum of four years experience in oncology, with postgraduate qualifications in a relevant health profession and specific training in facilitation of online, text-based support groups. A subgroup of the total participants were from specific rural support groups. The program was evaluated qualitatively, through postintervention interviews with 102 participants. These participants reported the need to adapt to online modes of communication but found convenience in being able to access support from their own home. A number of participants reported psychosocial benefits from sharing experiences with others and learning how others coped; however, this was not accompanied by objective assessment or comparison to a control condition.

Weinert et al published a series of papers evaluating three phases of the Women-to-Women intervention. Patient outcomes from phases 2 and 3 of this intervention were published in peer-reviewed journals and are reported here. Phase 2 consisted of a 22-week, asynchronous, text-based and online support group monitored by an advance practice nurse, accompanied by a structured program of CDSM health education units with discussion groups moderated by expert facilitators. The intervention was targeted specifically at middle-aged women with a range of chronic diseases living in rural regions of Western USA. A population-level advertising campaign promoted the study, and eligible women were screened by phone and randomly allocated to an intervention or control condition. Significant increases were observed in psychosocial adaptation (social support and self-efficacy) and health-related knowledge at six-month follow-up for the intervention group compared to the control. Based on phase 2 data suggesting that a less-intense intervention was similarly effective in increasing health-related knowledge as a more-intense intervention, phase 3 of the Women-to-Women program maintained the use of expert-moderated online discussion groups, but was explicitly redesigned to be shorter and less time-consuming for participants, in the interest of promoting retention. Additionally, retention was encouraged through a financial incentive provided at completion of the final mailed questionnaire. This trial recruited 309 rural women and replicated the previous findings of significant improvement in psychosocial adaptation (self-esteem, acceptance of illness) while also demonstrating a reduction in distress (depression, stress, and loneliness) at six-month follow-up for the intervention group compared to the control. Despite efforts to make the program less burdensome, phase 3 attrition rates were largely similar to those in phase 2 of the program. Attrition rates were higher in the intervention group than the control, raising the possibility that significant improvements in the intervention group may have been due to sicker patients being more likely to drop out of the intervention group. The authors conducted sensitivity analyses and imputed missing values and demonstrated that there was a minimal risk that significant effects might be explained by the differential dropout rates between the intervention and control groups.

Provider-mediated interventions. Cho et al conducted a randomized controlled trial of a 12-week, remote teleconsultation intervention among rural Korean patients with type 2 diabetes. Patients were allocated to have nurse-administered
glycated hemoglobin (HbA1c) tests uploaded for assessment and personalized feedback from a metropolitan diabetes specialist (N = 36), or a usual care control, in which nonpersonalized CDM education was provided by a rural primary health nurse (N = 35). Patients receiving the intervention showed a significant reduction in HbA1c and blood lipids at 12-week follow-up, compared to the control. In addition, patients in the intervention group undertook more blood glucose self-monitoring, which the authors interpreted to result from greater personal engagement in health-related behavior and CDSM.

Corriveau et al conducted a retrospective analysis of CDM measures among children with type 1 diabetes mellitus, before and after the implementation of the Carelink remote insulin pump telemonitoring system. Patient education and telemonitoring were provided by a certified diabetes educator, pump trainer, and registered dietitian. Among the 94 eligible patients, 61 had access to the Carelink system (41 users, 20 nonusers) and 33 lacked access (due to having an incompatible pump). Adherence was monitored and patients who failed to upload their insulin test results monthly received reminder phone calls. Patient notes were assessed for one year prior to commencement of Carelink, and up to two years post. Rural patients (37% of sample) showed a significant reduction in HbA1c post-Carelink adoption, compared to the nonuser and no-access comparator groups, who showed no such change.

Malone et al conducted an uncontrolled trial of a remote teleconsultation service for children with asthma in several remote American military stations across the Western Pacific. Primary care providers had access to facilities for uploading respiratory test results, and received CDM recommendations from pediatric pulmonologists, along with a specific pathway or plan for managing the condition. Only a small number of patients were recruited, and of these, only seven had complete follow-up data that were accessed from clinical notes. There was a significant reduction in symptom severity and healthcare utilization at follow-up, compared to baseline levels. However, there were no observable changes in patient adherence to medication or inhaler technique. The authors noted that primary care providers did not consistently follow the recommended pathway of follow-up monitoring.

Schrader et al conducted a small-scale, uncontrolled trial of a web- and mobile-based version of the Flinders program, among eight rural patients with chronic disease and comorbid mental illness. The Flinders program is an overarching, nondisease-specific approach to CDM, drawing on cognitive behavioral therapy and motivational interviewing, and targeting both patient and clinician behaviors. Nurses and community care workers used the program to enter treatment plans, while patients used the program to access health information. Patient use of the resource was hampered by technical difficulties and lack of confidence with computers and/or web-enabled phones. Self-reported health ratings completed at baseline and postintervention showed no statistically significant differences on any measures.

**User acceptance and feasibility.** In addition to trials assessing patient outcomes, a number of studies focused specifically on factors influencing user acceptance and feasibility of web-based CDM interventions in the rural setting, typically by assessing user perceptions qualitatively. Jernigan and Lorig reported that an online CDSM support-group program moderated by trained peers with chronic disease was accepted by patients with diabetes from a range of cultural backgrounds, with similar levels of engagement in an action planning component of the program across Caucasian and American Indian/Alaskan Native groups. However, time demands and access difficulties were reported to be significant barriers to accessing the program.

Guichler et al reported on user perspectives relating to a program of interactive, researcher-facilitated, video-conference support groups for rural patients with a range of chronic conditions. Participants reported a preference for face-to-face healthcare services but also acknowledged the ability of web-based interventions to reduce access barriers. Technical problems associated with the video-conferencing system were identified as hampering the effectiveness of the intervention, and the need for proactive facilitators was identified. Despite the fact that each video-conference session lasted over two hours, a number of participants expressed a preference for longer sessions, and private contact with the facilitator, to ask additional questions.

Weinert and Hill demonstrated that a simple education intervention, delivered in the context of an online support group, was effective in boosting the self-reported computer skills of rural women with chronic conditions and maintaining this improvement over time. Participants were also taught methods for evaluating the accuracy of health information accessed online. Computer skills have previously been shown to be associated with preferences for accessing health information online, satisfaction with web-based CDM interventions, and also to predict dropout from a web-based CDM intervention. The authors thus interpreted their ability to boost computer skills in this sample as evidence that web-based CDM interventions are feasible when accompanied by adequate support, even among populations without preexisting computer skills.

**Discussion**

This review aimed to evaluate the published evidence on the effectiveness and user acceptance of web-based CDM interventions for patients with chronic physical disease in rural areas. The review found only a small number of studies examining these questions. Among those studies with more rigorous designs and adequate samples of patients, there was some evidence of effectiveness in improving patient CDM and outcomes, both physiological and psychosocial.

Among the reviewed studies, interactive online groups were the most numerous and showed evidence of effectiveness. Studies using this treatment modality often recruited
patients with a range of chronic conditions. These interventions appeared to be effective in improving CDM within a range of domains, including health-related knowledge,⁴⁹ health behaviors,⁴⁴ and psychosocial adaptation, including social support.⁴³ Rural isolation is associated with reduced access to conventional healthcare services and may play a contributing role in the experience of chronic disease-related distress.⁴ Social support has been shown to provide a buffer against the cumulative negative effects experienced by patients with chronic disease, and interactive, online groups have been shown to be effective in increasing social support for patients in isolated, rural environments.⁵,⁴⁸ Provider-mediated teleconsultation interventions proved to be an effective means of supporting self-management among rural patients with chronic disease, while maintaining ready access to specialists when required. Studies employing this treatment modality tended to be disease-specific and focus on physiological indices of CDM, with evidence of effectiveness among those trials with more rigorous designs.⁴⁵,⁴⁹

Many of the studies reported were pilot or feasibility studies; there have been a few studies with large samples or rigorous controlled designs. This may be, in part, a product of the rural setting, in which smaller patient throughput and generalist, rather than specialist or disease-specific, health service delivery, can hamper case-finding for conventional clinical trials. The substantial samples recruited by Weinert et al in the latter phases of the Women-to-Women program may have resulted from broad inclusion criteria and use of population-level advertisement.⁵,⁴⁹ The advent of collaborative groups may in future enable recruitment of participants into transnational trials, potentially achieving the larger samples that will be required to establish statistical and clinical significance, particularly for disease-specific interventions.¹⁴ Attrition is an issue in many CDM interventions, including those delivered over the Internet.⁵⁰ Among the reviewed studies, attrition rates varied but were typically between 10% and 35%. As documented in previous similar reviews, attrition rates tended to be higher in the intervention, compared to the control condition.⁴ While such attrition rates do not seriously compromise the feasibility of online CDM as a mode of healthcare delivery, they can make it difficult to infer treatment efficacy from between-groups differences in clinical trials, particularly when attrition rates differ across experimental groups. Higher quality studies described the characteristics of participants who dropped out and used sensitivity analyses to quantify the potential bias from differential attrition rates.⁴ Interestingly, while some researchers made efforts to reduce the time demands of web-based interventions in an effort to promote retention,⁵,⁵⁷ other researchers have documented user preferences for longer sessions.⁴⁴ Researchers may consider strategies to improve retention, such as creating a project identity, establishing participant bonding with the project, encouraging collaborative effort, and rewarding participants.⁷⁷,⁵¹

Access to the Internet is a key mediator of web-based CDM interventions, and population-based studies indicate evidence of a persistent digital divide in rural areas.²⁰,³⁰ There is some evidence to suggest that rural patients are less likely to use computers or the Internet to seek health information.²⁰,²¹ However, Lear et al reported that among patients with cardiovascular disease, rurality ceased to predict access to home Internet when the researchers controlled for level of education. Consistent with this finding, Edwards et al reported that among patients with depression and cardiovascular disease, preferences for accessing health information via computers was associated primarily with confidence in using the technology, rather than geographic factors.³⁵ This suggests that preferences for accessing health information online among rural patients may be more related to what Winters et al termed compositional factors, such as education, self-efficacy, and computer skills, rather than contextual factors such as distance from specialist care. Such compositional factors are potentially malleable,⁵ hence user acceptance of web-based CDM interventions may be responsive to technical support interventions.³⁶,⁵² However, it is also important to recognize the difference between willingness to engage in short-term, goal-directed Internet searching for health information (assessed in most surveys), and willingness to use structured, and/or intensive web-based interventions over weeks or months. Retention rates in controlled trials should be considered when evaluating the acceptability of web-based interventions and should also contribute to judgments about risk of bias, when interpreting intervention effectiveness.

Data relating to user acceptance of online approaches to healthcare delivery among specific population groups is also scarce. For example, while some studies suggest promise in the use of telehealth and other online modalities for Indigenous populations,⁴⁰,⁴⁵,⁵³,⁵⁴ the majority of participants in trials of web-based CDM, to date (particularly in the United States, Canada, and Australia), have been of Caucasian descent. Ongoing work should focus on user-centered design principles in the development of web-based interventions for specific populations⁵⁵,⁵⁶ and include broader recruitment strategies in evaluation. Assessing the reasons reported by rural patients with chronic disease for dropping out of interventions will be another important indicator of design quality.⁵⁷

Limitations
This review has some limitations that should be considered in interpreting these findings. The small number of studies, and heterogeneity of study designs, meant that meta-analysis techniques such as funnel plots or sensitivity analyses could not be undertaken. Instead, the study characteristics were described, and a narrative synthesis was reported. There were only a small number of randomized controlled trials available for review. A number of reviewed studies did not describe the measures undertaken to ensure adherence to the intervention.

In order to detect studies conducted in rural or remote areas, the search strategy included the terms rural or remote; however, some relevant studies involving rural or remote patients

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may not have included these terms in the title or abstract, and hence would have missed. Accordingly, this review may not enable generalizations across all rural and remote settings. In an effort to address this limitation, the reference lists from other systematic reviews of online CDM interventions were manually screened (title and abstract). Finally, two studies identified during the initial search as potentially relevant were unable to be retrieved.

Conclusion

The studies reviewed here suggest that web-based CDM interventions can be effective for rural patients with chronic disease. The studies with stronger designs support the idea that health-related knowledge and psychosocial adaptation to chronic disease can be improved through web-based CDM. While this review has focused on rural patients with existing chronic disease, the increasing viability of web-based interventions suggests that they may also be an effective means of improving population health in rural areas, through mechanisms such as encouraging physical activity, improving nutrition, reducing alcohol consumption, assisting in smoking cessation, and coordinating healthcare delivery. Such interventions, when brought to scale and adequately promoted, may have a preventive impact and contribute to a reduction in the overall prevalence of chronic disease. For patients managing the existing chronic disease in rural areas, the challenges associated with reduced access to health services, social isolation, and stigma suggest that web-based interventions will remain an important component of rural chronic disease care. There is a need for further rigorous trials among rural populations to optimize the quality of these web-based interventions.

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Author Contributions

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