Models of care for sickle cell disease in low-income and lower-middle-income countries: a scoping review

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Sickle cell disease has a growing global burden falling primarily on low-income countries (LICs) and lower-middle-income countries (LMICs) where comprehensive care is often insufficient, particularly in rural areas. Integrated care models might be beneficial for improving access to care in areas with human resource and infrastructure constraints. As part of the Centre for Integration Science's ongoing efforts to define, systematise, and implement integrated care delivery models for non-communicable diseases (NCDs), this Review explores models of care for sickle cell disease in LICs and LMICs. We identified 99 models from 136 studies, primarily done in tertiary, urban facilities in LMICs. Except for two models of integrated care for concurrent treatment of other conditions, sickle cell disease care was mostly provided in specialised clinics, which are low in number and accessibility. The scarcity of published evidence of models of care for sickle cell disease and integrated care in rural settings of LICs and LMICs shows a need to implement more integrated models to improve access, particularly in rural areas. PEN-Plus, a model of decentralised, integrated care for severe chronic non-communicable diseases, provides an approach to service integration that could fill gaps in access to comprehensive sickle cell disease care in LICs and LMICs.

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Introduction

Non-communicable diseases (NCDs) comprise a growing proportion of the global burden of disease, including in low-income countries (LICs) and lower-middle-income countries (LMICs) where access to diagnostics and care for these conditions is often poor and only available in urban areas.[1] NCDs consist of a wide and diverse group of conditions, including sickle cell disease—a group of inherited red blood cell (RBC) disorders in which abnormal haemoglobin causes RBCs to become misshaped,[2] compromising the cells' oxygen delivery, and increasing destruction of RBCs and occlusion in blood vessels. This complex, multisystem NCD causes episodes of acute illness and progressive organ damage.[2]

Sickle cell disease remains a growing global disease, with an estimated 7·74 million individuals affected and 515 000 infants born with the condition worldwide in 2021.[3] The growing burden of sickle cell disease falls disproportionately on LMICs, particularly in sub-Saharan Africa, where approximately 80% of infants with sickle cell disease are born.[3] This region also has the highest mortality burden attributed to sickle cell disease. An estimated 29 400 people died of sickle cell disease in 2021 worldwide, representing an increase of about 30% since 2000.[3] Previous studies have estimated child mortality of 50–90% among children born in Africa with sickle cell disease.[4] Due to poor access to diagnostics and routine screenings for sickle cell disease in sub-Saharan Africa and other low-resource settings, researchers presume that most affected children die undiagnosed at a young age.

Since 2006, WHO has recognised sickle cell disease as a priority to raise awareness of the condition and improve access to health services.[5] However, a *Lancet Haematology* Commission[6] identified no progress in sickle cell disease care globally despite WHO's support and provided recommendations to reduce associated morbidity and mortality in LICs and LMICs. Sickle cell disease management consists of a wide range of services for paediatric and adult populations including, but not restricted to, pain management, administration of hydroxyurea (hydroxycarbamide), infection prophylaxis (including penicillin, pneumococcal vaccination, and antimalarials), blood transfusion, transcranial-doppler ultrasound screening, and bone marrow transplantation. Although these interventions have contributed to a reduction in mortality for patients with sickle cell disease in high-income countries,[7–9] these solutions are often not available or accessible to individuals in LICs and LMICs with the highest disease burden.[10] In resource-limited settings, access to specialised care centres remains poor.[6] A study from 2022,[10] identified factors including unavailability of medicines, high out-of-pocket costs, scarcity of required laboratory monitoring, and poor health-care facility infrastructure, such as trained health-care workers and laboratory capacity for monitoring, as barriers to access to sickle cell disease care.

Given the complexity of and large gaps in sickle cell disease care, efforts to expand access to care are essential and ongoing. Delivering a diverse set of interventions in health-care systems with substantial human resource and infrastructure constraints might require innovative strategies, including the use of integrated care delivery models as recommended by WHO.[11–13] Co-delivery of sickle cell disease services as part of integrated care might improve effectiveness and feasibility of introduction or ongoing provision of a heterogenous mix of interventions in LMICs, particularly at lower levels of the health-care system that are typically more geographically accessible to patients in rural areas compared with upper-level facilities located in urban centers. Although rural populations represent the majority of inhabitants in LICs and LMICs,[14] sickle cell disease care is poor in these areas compared with urban settings. Most people with sickle cell disease live in urban centres, but the largest unmet need for sickle cell care is found in rural areas, where a large number of

affected individuals possibly go undiagnosed and untreated.[15,16] Rural areas where care is often unavailable might particularly benefit from integrated models, as they can help overcome human resource and infrastructure-related barriers to deliver comprehensive care. As part of the Centre for Integration Science's ongoing efforts to define, systematise, and implement integrated care delivery models for NCDs,[17] this Review aims to examine models of sickle cell disease care provision in LICs and LMICs as a foundation for further research on integration of sickle cell disease services.

Methods

Search strategy and selection criteria

We completed a scoping Review of studies describing a model of care for sickle cell disease management. We included all studies done in LICs and LMICs (as classified at the time of the search by the World Bank Group)[18] published since Jan 1, 2000. We only included studies done in LICs and LMICs due to the unique implementation challenges in these settings. When the search yielded studies done in multiple countries, which included LICs and LMICs, and upper-middle-income or high-income countries, we included these studies but only analysed data from LIC and LMIC sites. Since models of care change over time, we made the decision to only include studies published since Jan 1, 2000. We included all study designs. As we were interested in sickle cell disease management, we excluded studies that only focused on sickle cell disease screening programmes and did not include management. These studies will be the focus of a subsequent study.

We searched PubMed, Embase, and African Index Medicus on August 22, 2022. The search terms included sickle cell disease, management terms, and LICs and LMICs. We excluded studies done in upper-middle-income countries or high-income countries. The full search strategy is shown in the appendix (p 3). To supplement the database search, we hand-searched reference lists of any reviews that we found. We also searched the earlier review by Adler and colleagues[17] for studies related to sickle cell disease. The search was restricted to a time frame of Jan 1, 2000, to Aug 22, 2022, and no additional restrictions were applied. The search yielded a small number of results in French and Portuguese, which were screened and, if determined relevant, extracted to the best of our ability with the aid of online translation tools.

See Online for appendix

Data collection and analysis

Data were downloaded and deduplicated in Endnote. The titles and abstracts were screened by two authors (LD and AT); 20% of abstracts were double screened. Disagreements were resolved by consensus, and in the case that consensus could not be reached, a third author (AJA) arbitrated. Once agreement was reached on the included studies, the titles and abstracts were screened again by two more authors. During screening, studies were restricted to those published in LICs and LMICs after Jan 1, 2000.

Full-text articles of papers were obtained for data extraction. Data were extracted using a piloted Microsoft Excel spreadsheet. In addition to information on sickle cell management, data on domains as defined by Adler and colleagues[17] were extracted, including information on the health-care system (table 1).

We classified studies by health-care system level when possible, based on the published information. These levels were divided into community, primary care (such as health centres), district (including district or first-level hospitals), tertiary (often referred to as provincial, secondary, or central hospitals), and specialised clinics that provide care for specific conditions as stand-alone facilities.

To categorise countries by prevalence of sickle cell disease, Global Burden of Disease estimates were used and grouped based on sickle cell disease prevalence.[1] Low prevalence of sickle cell disease was defined as less than three cases per 10 000 individuals. Medium prevalence was defined as three to ten individuals per 10 000 individuals. High prevalence was defined by greater than ten cases per 10 000 individuals.

Management of acute and chronic sickle cell disease complications is a key component of comprehensive sickle cell disease care models. To understand the scope of sickle cell disease complications addressed with existing management in LICs and LMICs, one haematologist and one haematology fellow categorised clinical applications of management based on organs commonly affected by sickle cell disease and their associated complications and outcomes (appendix p 2). For a subset of studies that reported on effectiveness of management on these clinical applications, the management services provided were quantified for each clinical application. Given heterogeneity in the measures of management, clinical applications, and effectiveness used across studies, quantification of effectiveness itself was not done.

Narrative synthesis of the types of studies describing integration was done. Percentages of studies in each category are provided.

Assessment of risk of bias

This Review includes studies describing models of care; effectiveness or other measurements were not evaluated. For that reason, a risk of bias assessment was not done. We acknowledge the inherent risks in doing scoping reviews and address these in our Review.

Results

The initial search yielded 6430 records (figure). Initial screening yielded 385 records. A second titles and abstract screening reduced the number of records to 174. Full texts were retrieved, and 40 were excluded. Two additional relevant studies were identified from handsearching of references. Several studies or settings were included in multiple papers. Where appropriate, both the number of

	Number of studies (n=99)	Number of papers (n=136)
Income group		
Low-income country	21 (21%)	28 (21%)
Lower middle-income country	73 (74%)	97 (71%)
Countries of different income levels	5 (5%)	11 (8%)
Region		
Sub-Saharan Africa	62 (63%)	88 (65%)
North Africa and Middle East	8 (8%)	8 (6%)
Europe and central Asia	0 (0·0%)	0
South Asia	24 (24%)	28 (21%)
East Asia and the Pacific	0	0
Latin America and Caribbean	2 (2%)	7 (5%)
Multiple regions	3 (3%)	5 (4%)
Prevalence of sickle cell disease		
Low (<3 cases per 10 000)	6 (6%)	7 (5%)
Medium (3–10 cases per 10 000)	49 (50%)	67 (49%)
High (>10 cases per 10 000)	41 (41%)	58 (43%)
Countries of different prevalence	3 (3%)	4 (3%)
Health-care system level		
Community	1 (1%)	1 (1%)
Primary care facilities	2 (2%)	2 (12%)
District	3 (3%)	4 (3%)
Tertiary	67 (68%)	94 (69%)
Specialised clinics	7 (7%)	7 (5%)
Unspecified or multi	19 (19%)	28 (21%)
Delivery area		
Rural	4 (4%)	7 (5%)
Urban	82 (83%)	107 (79%)
Mixed	1 (1%)	4 (3%)
Not specified or mixed	13 (13%)	18 (13%)
Scale		
Single centre	72 (73%)	99 (73%)
Multi centre	18 (18%)	20 (15%)
Multi country	6 (6%)	12 (9%)
Not specified or mixed	3 (3%)	5 (4%)
Institution		
Public	55 (56%)	76 (56%)
Public with outside support	7 (7%)	12 (9%)
Private	7 (7%)	9 (7%)
Non-governmental organisations	8 (8%)	9 (7%)
Not specified	22 (22%)	30 (22%)
Site of care provision		
Sickle cell clinic, unspecified	24 (24%)	36 (27%)
Sickle cell clinic, paediatric	7 (7%)	16 (12%)
Haematology clinic, unspecified	7 (7%)	8 (6%)
Haematology clinic, paediatric	3 (3%)	6 (4%)
Outpatient clinic, general	3 (3%)	3 (2%)
Outpatient clinic, paediatric	2 (2%)	3 (2%)
Acute care clinic, unspecified	0	0
Acute care clinic, paediatric	1 (1%)	1 (1%)
Emergency department	1 (1%)	1 (1%)
Emergency department, paediatric	1 (1%)	1 (1%)
Inpatient	2 (2%)	2 (2%)
Inpatient, paediatric	2 (2%)	2 (2%)
Other specialised clinic	4 (4%)	4 (3%)
Community control centre	1 (1%)	1 (1%)
Maternal and child health clinic	1 (1%)	1 (1%)
Bone marrow transplantation centre	3 (3%)	3 (2%)
Unspecified	36 (36%)	47 (35%)
Personnel who delivered the care		
Midlevel health-care provider	3 (3%)	4 (3%)
Generalist physician	2 (2%)	3 (2%)
Specialist physician	1 (1%)	1 (1%)
Multi cadre	6 (6%)	8 (6%)
Unspecified	86 (87%)	121 (90%)
Ultrasound technician	1 (1%)	1 (1%)
Delivery model classification		
Theoretical research protocols (not yet implemented)	2 (2%)	6 (4%)
Pilot and feasibility studies	16 (16%)	28 (21%)
Experimental studies	11 (11%)	13 (10%)
Embedded in routine care or evaluation	70 (71%)	91 (67%)
Paediatric or general		
Specified paediatric	46 (47%)	75 (55%)
Adults or combination	46 (47%)	54 (40%)
Not reported	7 (7%)	9 (7%)
Management		
Hydroxyurea (hydroxycarbamide)	54 (55%)	82 (60%)
Pain medications	7 (7%)	10 (7%)
Blood transfusion	25 (25%)	31 (23%)
Pneumococcal conjugate vaccine and penicillin prophylaxis	9 (9%)	13 (10%)
Transcranial doppler ultrasound	10 (10%)	18 (13%)
Haematopoietic cell transplantation	4 (4%)	4 (3%)
Other	11 (11%)	11 (8%)

Data shown are n (%). Studies are classified by income level, region, delivery area, scale, institution, research role in delivery model, and condition category.[37]

Table 1: **Characteristics of the studies included**

models (number of unique settings) and the number of papers were reported. In total, 99 models from 136 papers were included (appendix p 4).[19–156]

73 (74%) of 99 studies were from LMICs and 21 (21%) 99 were done in LICs. Five studies reported in 11 papers came from multiple countries in different settings (table 1).

62 (63%) of 99 studies came from sub-Saharan Africa, followed by South Asia with 24 (24%) studies (table 1). Eight came from North Africa and the Middle East and two from Latin America. Three studies took place across multiple regions. There were no studies included from Europe and central Asia, or east Asia and the Pacific.

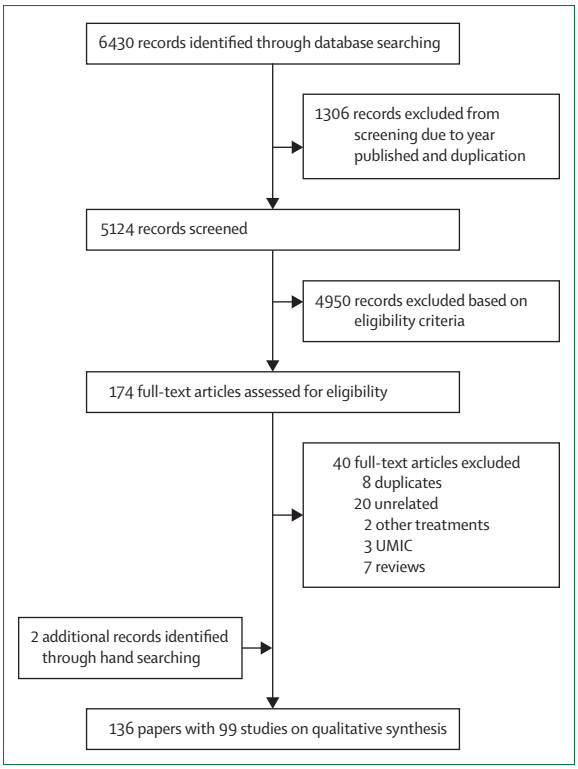

Figure: **Flow diagram of studies included in our Review**
UMIC=Upper-middle-income countries

	Low-income countries (n=21)	Lower-middle-income countries (n=73)
Specified paediatric	14 (67%)	30 (41%)
Included adults	6 (29%)	38 (52%)
Not applicable or unspecified	1 (5%)	5 (7%)
Prevalence of sickle cell disease		
Low	5 (24%)	1 (1%)
Medium	9 (43%)	38 (52%)
High	6 (29%)	34 (47%)
Multiple prevalence levels (multi-country)	1 (5%)	..
Services provided		
Transfusion	10 (48%)	16 (22%)
Hydroxyurea (hydroxycarbamide)	8 (38%)	43 (59%)
Pain medication	0	3 (4%)
Pneumococcal conjugative vaccine alone or in combination with penicillin prophylaxis	3 (14%)	7 (10%)
Allogeneic Haematopoietic cell transplantation.	0	4 (6%)
Transcranial doppler	2 (10%)	9 (12%)
Other	2 (10%)	9 (12%)

Table 2: **Characteristics of studies by income level**

The lowest number of studies came from countries with a low prevalence of sickle cell disease (six [6%] of 99 studies; table 1). There was a similar number of studies from countries with a medium (49 [50%]) and high (41 [41%]) prevalence of sickle cell disease. A high number of studies from medium prevalence countries were done in India.

Among studies in which we were able to differentiate health-care system levels (80 [81%] of 99), 67 came from tertiary care settings, such as teaching or provincial-level hospitals (table 1). Just 6% of studies among those reporting on health system level took place at lower facility levels, 1% were done at the community level, 2% at the primary care level, and 3% at the district level. Care for patients was provided in specialised sickle cell disease clinics in 31 (31%) of 99 studies, or in haematology clinics (ten [10%] of 99; table 1). Only in five studies was care provided in general outpatient clinics. These five studies came from a variety of countries: Nigeria, Democratic Republic of the Congo, and Sudan.

In 86 (87%) of 99 studies the health-care provider was not reported (table 1). In the 11 studies that did report the provider type, care was most commonly delivered by teams consisting of multiple cadres. In the remaining studies, provider types included three midlevel physicians, two generalist physicians, and one specialist physician.

70 (71%) of 99 studies included in this Review described routine care provided at established clinics rather than research studies (table 1). Research studies consisted of 16 pilot and feasibility studies, and 11 experimental studies.

Regarding study populations, 14 (67%) of 21 studies done in LICs specified paediatric populations, compared with 30 (41%) of 73 studies done in LMICs (table 2). In high-prevalence settings, only 13 (32%) of 41 studies included adults, whereas 25 (61%) studies specified paediatric patients only (table 3). Studies in medium-prevalence countries were more inclusive to adults with sickle cell disease, with 30 (63%) of 48 study populations including patients aged more than 18 years (table 3). All studies focusing on pain management were from LMICs; no LICs reported pain management data.

Hydroxyurea, provided within both routine care in 36 cases and research activities in 18 cases, was by far the most common treatment and was reported in 54 (55%) of 99 studies (table 1). About 25% of studies described use of blood transfusion. Studies discussing hydroxyurea and transfusion were similarly represented in LICs (with ten and eight studies, respectively), but studies discussing hydroxyurea were more common in LMICs, with 43 studies.

The greatest number of studies reporting on the clinical applications of sickle cell disease management involved treatment aimed at acute complications and outcomes of sickle cell disease. 36 studies focused on reducing pain, 33 on reducing anaemia, 25 on reducing hospitalisation, and 23 on reducing mortality (table 4). Of studies reporting on pain, transfusion and hydroxyurea treatment were the most commonly provided services. These

services were also reduction of hospitalisation, anaemia, and mortality. Provision of interventions related to other clinical applications varied. For example, penicillin prophylaxis was the most common intervention in 13 (68%) of 19 studies reporting on reduction of non-malarial infections.

We identified only two examples of integration of sickle cell disease care into settings providing care for other conditions. One such example occurred in Angola, where a sickle cell disease programme was established at a maternal and child health hospital.[99] This urban programme provided a comprehensive range of free services for sickle cell disease, including hydroxyurea, pneumococcal vaccination, folic acid supplementation, and penicillin prophylaxis, administered by a multi-cadre team. Another study in Kibera, Kenya described a primary care facility that provided integrated care for several NCDs, including sickle cell disease, in one programme with the use of task shifting of disease management to nurses.[105] Rather than integration, we identified many instances of increased specialisation of sickle cell disease care through establishment of specialised sickle cell disease clinics and care teams.[27,28,103,107,134] One example took place in Malawi, where children with sickle cell disease initially received care within a general paediatric outpatient department before initiation of a specialised sickle cell disease clinic with a dedicated care team.[20]

Discussion

To our knowledge, our Review is the first to offer insight into existing models for sickle cell disease care in LICs and LMICs. These results show that, based on the literature, care for sickle cell disease is mostly found in specialised clinics located in urban tertiary settings in LICs and LMICs. There is little evidence in the published literature for integrated models of care for sickle cell disease. Only in India were there examples of care for sickle cell disease in rural settings. We identified only two models of integration of sickle cell disease care with other conditions despite WHO's recommendations for integrated models of care in LICs and LMICs. We identified several models of care that instead reported on increased specialisation of sickle cell disease care through establishment of sickle cell disease-specific clinics and care teams.

Hydroxyurea and transfusion were the most common treatments, with hydroxyurea being more common in LMICs. Management focused more on acute complications than on chronic complications of sickle cell disease, with acute pain most commonly addressed. This tendency is possibly due to low childhood survival and limitations in diagnostic and therapeutic management of long-term sickle cell disease complications beyond childhood.[4] There was some indication that there are more models occurring in paediatric clinics in LICs, possibly reflecting the fact that without treatment many individuals with sickle cell disease die during their childhood, which

	Low prevalence (n=6)	Medium prevalence (n=48)	High prevalence (n=41)
Specified paediatric	4 (67%)	16 (33%)	25 (61%)
Included adults	1 (17%)	30 (63%)	13 (32%)
Not applicable or not reported	1 (17%)	2 (4%)	5 (7%)
Income level			
Low-income country	5 (83%)	9 (19%)	6 (15%)
Lower-middle-income country	1 (17%)	38 (79%)	4 (10%)
Countries of different income levels	0 (0%)	1 (2%)	1 (2%)
Services provided			
Transfusion	2 (33%)	14 (29%)	9 (22%)
Hydroxyurea (hydroxycarbamide)	3 (50%)	24 (50%)	25 (61%)
Pain medication	0 (0%)	4 (8%)	1 (3%)
Pneumococcal conjugate vaccine, penicillin prophylaxis	0 (0%)	6 (13%)	4 (10%)
Allogeneic HCT	0 (0%)	4 (8%)	0 (0%)
Transcranial doppler	1 (17%)	3 (6%)	7 (17%)
Other	1 (17%)	8 (17%)	1 (2%)

HCT=haematopoietic cell transplantation.

Table 3: **Characteristics of studies by sickle cell disease prevalence**

	Transfusion	Hydroxyurea (hydroxycarbamide)	Penicillin prophylaxis	Pain management	Allogeneic haematopoietic cell transplantation
Hospitalisation (n=25)	11 (44%)	19 (76%)	10 (40%)	6 (24%)	0
Eyes (n=0)	0 (0%)	0 (0%)	N/A	N/A	0
Anaemia (n=33)	16 (48%)	18 (55%)	N/A	N/A	0
Primary prevention of stroke (n=9)	5 (56%)	7 (78%)	N/A	N/A	0
Secondary prevention of stroke (n=7)	3 (43%)	7 (100%)	N/A	N/A	0
Treatment of stroke (n=3)	3 (100%)	1 (33%)	N/A	N/A	0
Unspecified neuropathology (n=9)	5 (56%)	6 (67%)	N/A	N/A	0
Pulmonary (n=15)	6 (40%)	11 (73%)	9 (60%)	4 (27%)	0
Spleen (n=8)	4 (50%)	7 (88%)	N/A	3 (38%)	0
Skin (n=2)	2 (100%)	2 (100%)	2 (100%)	1 (50%)	0
Pain (n=36)	26 (72%)	26 (72%)	N/A	12 (33%)	0
Non-malarial infections (n=19)	9 (47%)	11 (58%)	13 (68%)	N/A	0
Bone (n=3)	2 (67%)	3 (100%)	N/A	1 (33%)	0
Genitourinary (n=6)	4 (67%)	5 (83%)	N/A	2 (33%)	0
Gallbladder (n=1)	1 (100%)	1 (100%)	1 (100%)	1 (100%)	0
Cardiovascular (n=2)	1 (50%)	2 (100%)	N/A	N/A	0
Mortality (n=23)	11 (48%)	12 (52%)	9 (39%)	7 (30%)	3 (13%)

N/A=not applicable.

Table 4: **Clinical applications and services available in the studies included**

might be more likely in the most resource constrained settings compared with higher-resource settings.

Surprisingly, pain management was reported only at LMICs, with no studies from LICs reporting on pain management services offered at care facilities. As pain management is a key component of sickle cell disease care, facilities in these studies with possibly poor resources might not offer intravenous pain medications and patients rely on oral pain medicines at home.

Evidence suggests that at the time of conducting this Review, efforts to decentralise care for sickle cell disease are insufficient. Integrated care for sickle cell disease is particularly poor in rural areas of LICs and LMICs, where integrated models might be the most advantageous to expand access to care. Since literature has reported high morbidity and mortality associated with sickle cell disease in LICs and LMICs, particularly in sub-Saharan Africa, there is a great need to develop and implement delivery models that integrate sickle cell disease care into general care or alongside services for other conditions at lower-level health facilities.

In the current Review we found only four (4%) of 99 studies took place in rural areas, and only one was community-based. In comparison, 25% of models occurred in community settings and 25% in rural regions, in a study looking at overall integrated models of care for NCDs.[17] 71% of studies in this Review were based in embedded models compared with only 47% in the overall NCD review.[17] Only two studies described sickle cell disease care integrated into a non-sickle cell disease care setting.[99,105] To ensure we were finding all models of integrated care, we checked all integrated models of care as published by Adler and colleagues.[17] We only found one additional model of sickle cell disease integrated with treatment for other conditions, but only for sickle cell disease screening, which is outside of the scope of this Review.

We found that only five studies from three countries (Democratic Republic of the Congo, Nigeria, and Sudan) described care provided in non-specialised outpatient settings. Many studies instead reported on the establishment of specialised care programmes exclusively for sickle cell disease. Both the low numbers of studies occurring in rural areas or low-level facilities, and the low number of experimental studies focusing on service integration, suggest that there is an insufficient push to decentralise care for sickle cell disease compared with efforts in this area for other NCDs.

Our Review has some limitations. The search was restricted to only reflect published, peer-reviewed literature. Therefore, this study does not capture all models of sickle cell disease that might be in place in LICs and LMICs. Although we did not exclude studies on the basis of language, we utilised only English search terms and our search might have missed models published in other languages. Similarly, extraction and analysis of studies included was restricted to information published in articles and therefore might not be complete. We used methods to accurately depict models of care based on the articles, but potential inaccuracies remain a limitation of this study type. Finally, this Review excluded studies reporting exclusively on screening activities. Screening programmes for sickle cell disease are key for diagnosis and subsequent management. Given the rapid expansion of screening programmes in LICs and LMICs and the vast amount of associated literature during the study period, we believe that a dedicated review focused on sickle cell disease screening should be done.

Results of this Review suggest that integrated care for sickle cell disease is insufficient in rural areas of LICs and LMICs where it might be most advantageous. Our review of the literature showed few examples of integrated care for sickle cell disease. Comprehensive sickle cell disease care includes a wide and diverse range of services. In addition to treatments discussed here, such as hydroxyurea and blood transfusion, the combination of point-of-care tests to diagnose sickle cell disease and low-cost interventions, such as guardian education, penicillin prophylaxis, insecticide-treated nets, and vaccinations should be universally deployed to enhance the care of patients with sickle cell disease. Introduction and implementation of such interventions is possibly more feasible and effective within integrated care delivery platforms than as standalone services. Given the high morbidity and mortality associated with sickle cell disease in LICs and LMICs, there is a great need to develop more models of integrating care for people living with sickle cell disease into general care in rural areas, as recommended by WHO.[3] One such method is to incorporate care for sickle cell disease into existing NCD clinics. PEN-Plus is a model of integrated care for severe chronic NCDs that has been incorporated in rural areas of LICs.[155] Originally PEN-Plus was designed for cardiac conditions and type 1 diabetes, but has since been expanded to incorporate care for sickle cell disease.[157] PEN-Plus presents a much-needed model for integrated sickle cell disease care in mid-level facilities in rural areas, where care is often unavailable or inadequate. Based on our findings, implementation of PEN-Plus in these areas might help fill a large gap in access to comprehensive sickle cell disease care.

Conclusions

This Review examined models of sickle cell disease care in LICs and LMICs to inform further research on the provision and integration of sickle cell disease services. We found that in LICs and LMICs, sickle cell disease care is typically provided in specialised clinics in urban, tertiary settings and focused on management of acute complications. The absence of published evidence of sickle cell disease care in rural settings and very few examples of sickle cell disease care integrated with other types of conditions show a need to implement integrated care models to improve access, especially at low-level health facilities in rural areas. One such model is

PEN-Plus—a strategy for decentralised, integrated care for severe chronic NCDS currently implemented in several LICs and LMICs, which in 2018 expanded in scope to include sickle cell disease services. PEN-Plus provides a promising approach to service integration that could fill a large gap in access to comprehensive sickle cell disease care in low-resource settings.

Contributors

Conceptualisation and design: LD, MO, NA, GB, and AJA. Data collection: LD, AT, and AA. Data analysis and interpretation: LD, MO, AT, CB, NA, and AA. Drafting the article: LD, MO, AT, CB, NA, GB, and AA.

Declaration of interests

We declare no competing interests.

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