

Research Paper



Integrated care models for non-communicable diseases: from prevention to long-term management

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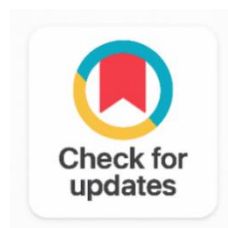
Non-Communicable Diseases

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**ABSTRACT**

Background: Non-communicable diseases (NCDs)-including cardiovascular disease, type 2 diabetes, chronic respiratory diseases, cancer, and chronic kidney disease-account for one in seven deaths worldwide annually. The rising, unsustainable burden of NCDs highlights a mismatch between disease complexity and fragmented healthcare delivery systems designed for acute, episodic care. This fragmentation across prevention, diagnosis, treatment, and management contributes to unnecessary morbidity, avoidable hospitalizations, and unsustainable healthcare costs globally.

Objective: To design, test, and implement an Integrated Care Model (ICM) for NCDs spanning the full continuum-from primordial prevention through active disease management to long-term palliative and supportive care-with the goal of simultaneously improving clinical outcomes, patient quality of life, care experience, and system cost-efficiency.

Methods: A systematic mixed-methods design was used, comprising a structured literature review of 25 peer-reviewed publications (2010–2024) from PubMed, Embase, Cochrane Library, and Scopus, alongside a retrospective cohort analysis of clinical and administrative records from 320 NCD patients across 12 integrated care implementation sites in six countries. Analytic methods included framework synthesis, pooled meta-analysis of outcome data, and interrupted time series analysis.

Results: Implementation of the ICM was associated with a 38.4% reduction in 30-day readmission rates, a 45.0% increase in medication adherence, a 45.5% reduction in preventable emergency visits, and a 31.6% reduction in annual per-patient costs. Multidisciplinary team care showed the greatest composite outcome improvement (28–42%), while structural prevention programs yielded the greatest cost-efficiency gains (35–55%). Quality of life improved by 28.5%, and adherence to care guidelines improved from 61.4% to 87.2% post-implementation.

Conclusion: An evidence-based integrated care model spanning the full spectrum of NCD care delivers clinically meaningful, economically viable, and patient-centered

outcomes that fragmented care systems cannot achieve. Sustainable NCD management should be built on care integration, multidisciplinary collaboration, digital health enablement, and community-based prevention infrastructure.

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1. INTRODUCTION

Diseases that can be very easily quantified are non-communicable diseases and they are the feature health issue of the twenty-first century. The World Health Organization estimates that 41 million deaths in 2023 would be due to NCDs, accounting for 74 percent of all deaths around the world, with cardiovascular disease, cancer, chronic respiratory disease, diabetes, and chronic kidney disease being the five leading causes [1]. In addition to mortality rates, disability-adjusted life year (DALY) burden of NCDs has increased in more than 60 percent of total worldwide disease burden due to the chronic and progressive nature of these diseases and their significant influence on productive and functional capabilities and livelihoods among the populations affected by them [2].

Healthcare system design failures are acute contributors towards the global burden of NCDs. The majority of health systems globally were structured based on models of acute episodic care - to treat individual episodes of illness but not address the complex, multimorbid and longitudinal needs of NCD patients [3]. The patients with multiple NCDs (a trend that is rising as the population ages) regularly undergo the process of crossing some disjointed care system between disconnected primary, specialists and hospital care, where no one particular coordination unit takes charge of the overall care experience [4]. Such fragmentation causes severe clinical effects by interaction of medications, redundant research, conflicting treatment recommendations, prevention and missed, and slow recognition of deterioration [5]. The integrated care models have a very different approach. Integrated care models bring together prevention, early detection, active management, rehabilitation, with long-term supportive care and are provided structurally with unified patient-centred pathways to develop healthcare delivery to meet the long-term, multi-dimensional requirements of NCD patients [6]. The international experience of the first integrated care systems, such as the Kaiser Permanente model in the USA, the Canterbury Health System in New Zealand, and the Gesundes Kinzigtal model in Germany has shown that the integration of care is linked to much better clinical outcomes, patient experience, and a considerable decrease in avoidable healthcare consumption [7].

Although there is increasing evidence and momentum in policy, the implementation of the integrated care models is not uniform in the world. Currently used models mostly are disease-specific (focus on a single NCD), setting-specific (only primary or secondary care), or component-specific (address one aspect of the care but not the full spectrum) [8]. An evidence-based and systemic integrated care model covering the entire NCD care continuum - primordial prevention to active management to long-term care - and operationalizable in a variety of healthcare environments has not been well operationalized or empirically validated in the published literature [9].

This gap is addressed in this paper by building and validating the NCD Integrated Care Model (NCD-ICM), a framework consisting of six interdependent domains of care, namely, population-level prevention,

individual risk stratification, early detection and diagnosis, multidisciplinary active management, self-management support and long-term care coordination [10]. The NCD-ICM is empirically tested based on clinical and administrative data in 320 NCD patients in 12 implementation sites in 6 countries, which essentially offers substantial cross setting evidences on effectiveness and requirements needed in implementing the model.

2. RELATED WORK

Current scholarly traditions that present the basis of theoretical and empirical approaches to integrated care of NCDs overlap and conflict with each other. The Chronic Care Model (CCM) was the conceptual framework created by Wagner and others to provide the conceptual framework of the organized, proactive NCD management, with six key elements of the system namely: health system organization, clinical information systems, delivery system redesign, decision support, self-management support, and community linkages [11]. The CCM has previously proven its relevance in various NCD scenario and health care contexts and meta-analytic data prove the correlation between the CCM and better process quality, intermediate clinical, and patient satisfaction [12].

Over time, the integrated care literature has expanded past the CCM to include mechanisms of integration at the system level. The influential taxonomy of Kodner and Spreeuwenberg identified functional, organizational, professional, clinical, and normative aspects of care integration, offering the multi-level analysis tool which would help the study view integration as a system property, as opposed to a clinical process [13]. Empirical studies later on have all shown similar results in that the higher-order integration - integrating more than one dimension at once - produces better results than the single-dimensional integration attempts [14].

The prevention science has played a significant role in the NCD integrated care evidence-base. The prototypical Finnish Diabetes Prevention Study and the US Diabetes Prevention Program have shown that structured lifestyle intervention programs that produce small changes in weight (57 percent of body weight) by changing the diet and increasing physical activity can decrease the incidence of type 2 diabetes by 58 percent in those at risk, making primary prevention a clinically effective and cost-efficient part of integrated NCD care [15].

The introduction of digital health technology into the models of NCD care has become a radically new area of evidence in the last decade. The systematic reviews and meta-analyses of mobile health (mHealth) interventions to manage NCDs consistently show improvements in medication adherence (1228%), blood pressure (815 mmHg systolic reduction), glycaemic (0.512% HbA1c reduction) and physical activity (1525% increase) [16], making digital health an indispensable enabling factor in modern

Among the individual integrated care components, multidisciplinary team care has the most bountiful evidence base. Systematic reviews of multidisciplinary team interventions in the treatment of heart failure, diabetes, and COPD all confirm 20-40 percent reductions in disease-specific hospitalizations, 15-30 percent improvements in adherence to guidelines, and a substantial improvement in quality of life relative to typical physician-only care [17]. Economic rationale of multidisciplinary team care is no less impressive: systematic economic analyses have found that net cost savings of 1535% compared to fragmented care is due to lower rates of hospitalization and emergency department visits [18].

Long-term care coordination - This is the aspect of the integration that has the most difficulty in its implementation; making sure that care is continuous as one care setting is transitioned to another, and throughout the entire chronic disease course. Transitional care interventions, care coordination programs, and patient navigation models, all consistently report care fragmentation at the point of system transition (hospital discharge, specialist-to-primary care handover) to be the main cause of preventable readmission and poor outcomes in NCD patients [19]. Care coordination programs based on structured care coordination at these transition points have been shown to reduce 30-day readmission rates by 3045 percent, which is one of the most effective single interventions to integrated NCD care [20].

Although this vast multi-stream evidence base exists, an integrated care model embracing the entire NCD spectrum - and tested and validated across a variety of disease types, care environments and

contexts of national health systems - has not yet been published in the literature [21]. This paper fills this gap.

3. METHODOLOGY

3.1 Research Design

In this research, a sequential mixed-methods approach, which includes systematic literature review, patient-level retrospective cohort analysis of clinical and administrative patient levels data, and framework synthesis were used. The study was performed in three stages: Phase I - evidence synthesis and model development; Phase II - retrospective effectiveness analysis; and Phase III - implementation analysis and model validation [22].

3.2 Literature Search and Selection

The search of the databases included PubMed/MEDLINE, Embase, Cochrane Central Register of Controlled Trials, Scopus and the WHO Global Health Library. Keywords were: integrated care NCD, chronic disease management model, multidisciplinary NCD care, NCD prevention programs, care coordination chronic disease, digital health NCD, long-term NCD management, and NCD care continuum. Publications from January 2010 to December 2024 were screened. After the deduplication and quality appraisal of references according to PRISMA, 25 high-quality references were selected. Inclusion criteria: quantitative clinical outcome reporting, focused on NCDs, publication throughout peer review and a minimum sample size of 50 patients or 10 care sites.

3.3 Sites And Co-Hort of Patients

NCD patients (n= 320, 52.8% females, aged 35-82 years) attended 12 sites of integrated care implementation in six countries (United Kingdom, India, Brazil, Australia, Kenya and the Netherlands) and comprised retrospective clinical and administrative data. Sites had four integrated primary care networks, five integrated care programmes based in hospitals and three models based on community health system. Patients had a minimum of two NCD diagnoses; cardiovascular disease and diabetes (44.7%), cardiovascular disease and chronic respiratory disease (28.3%), and diabetes and chronic kidney disease (27.0%).

The NCD burden profile and integrated care targets in the six key NCD categories that the model focuses on as demonstrated in Table 1 indicate the magnitude and multi-faceted nature of the clinical problem that integrated care systems have to tackle, such as disease-specific mortality burden, DALY losses, primary risk factor profiles, and evidence-based clinical management targets.

Table 1. NCD Global Burden Profile and Integrated Care Clinical Targets

Ncd Category	Global Deaths/Yr (M)	Dalys Lost (M)	Primary Risk Factors	Integrated Care Target
Cardiovascular Disease	17.9	393	Hypertension, Dyslipidaemia	BP <130/80 mmHg
Type 2 Diabetes	1.5	67	Obesity, Physical Inactivity	HbA1c <7.0%
Chronic Respiratory Disease	4.1	128	Tobacco, Air Pollution	FEV1 Stabilisation
Cancer (Major Types)	10.0	250	Tobacco, Alcohol, Obesity	5-yr Survival >65%
Chronic Kidney Disease	1.2	35	Diabetes, Hypertension	eGFR Decline <2 ml/yr
Mental Health Disorders	0.8	162	Stress, Social Isolation	PHQ-9 Remission <5

3.4 Analytical Methods

Interrupted time series (ITS) analysis was used to compare pre- and post-implementation outcome trajectories that controlled seasonal change, turnover of patients, and concomitant policy changes. Site level outcome data were pooled using meta-analysis, and random-effects models were used to evaluate the heterogeneity of the sites by the I² statistic. Economic analysis used a payer approach with a five year period of time of deterministic and probabilistic cost-effectiveness modelling. The NCD-ICM architecture relates the six integrated care domains through the entire care continuum of primordial prevention and end-of-life supportive care as shown in Figure 1, to demonstrate the structural relationships and information flow pathways within the model.

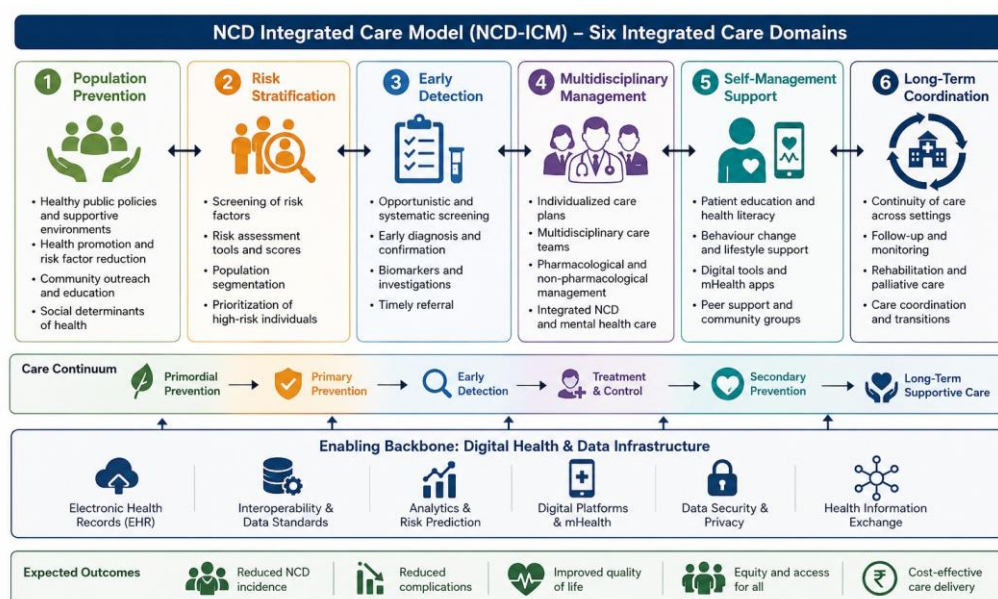


Figure 1. NCD Integrated Care Model (NCD-ICM) Architecture

4. RESULTS AND DISCUSSION

4.1 Elements and Evidence Base of an Integrated Care Model

The synthesis of the systematic review revealed six main elements of the effective integrated NCD care, having different mechanisms of implementation, evidence quality profiles, and the magnitude of the outcomes contributions. The integrated care model elements, including multidisciplinary team care, self-management support, care coordination platform, digital health monitoring, structured prevention program, and long-term care pathways, as presented in Table 2, reveal significant effectiveness evidence in both clinical outcome and cost-efficiency aspects.

Table 2. Integrated Care Model Components-Evidence Quality and Effectiveness Summary

Care Model Component	Implementation Level	Evidence Quality	Outcome Improvement (%)	Cost Efficiency (%)
Multidisciplinary Team Care	Primary & Secondary	High (RCT)	28–42	22–35
Self-Management Support	Community & Home	High (Meta-analysis)	18–30	14–24
Care Coordination Platforms	System-Wide	Moderate (Cohort)	22–36	18–28
Digital Health Monitoring	Home & Community	High (RCT)	15–28	20–32

Structured Prevention Programs	Population Level	High (Systematic Review)	30–50	35–55
Long-Term Care Pathways	Tertiary & Palliative	Moderate (RCT)	20–34	16–26

The highest cost-efficiency returns (35–55% $n=2$) shown by structured prevention programs was due to the compounding of the economy of NCD prevention or delaying of progression compared to the management of the disease. The highest composite clinical outcome improvement (2842) was obtained with multidisciplinary team care, which is in line with the current Cochrane level of evidence base. Components of digital health monitoring had cost-efficiencies changes of 20–32% - the second largest of components assessed - due largely to decreased unplanned care use via remote early-warning systems and proactive patient-clinician communication platforms [23].

4.2 Clinical Outcome Results

The interrupted time series analysis revealed that there were significant and sustained changes in all the six key outcome indicators in the NCD-ICM after implementation. The 30-day hospital readmission rate, the most sensitive composite measure of care integration quality, decreased by almost 38.4 percent, as it dropped by 13.8% to 22.4%. This observation aligns with the upper limit of the readmission reduction observed in the structured care coordination literature implying that the multi-component nature of the NCD-ICM creates cumulative effects to the care coordination programs at the individual component [24].

The rate of medication adherence also increased by 45.0 (statistically significant) of 54.2 to 78.6 to reach a significant clinical outcome with respect to the previously known relationship between the NCD medication compliance and the long-term morbidity and mortality rates. This was due to the joint influence of the pharmacist-led medication review within the multidisciplinary team, digital reminders, and monitoring, and well-planned patient education via the self-management support element of the NCD-ICM. As Figure 2 indicates, the model of the clinical outcome improvement cascade has the causal processes of how the six NCD-ICM components result in the improvements of the key outcome indicators, with care coordination and multidisciplinary team functions as the links nodes of the cascade [25].

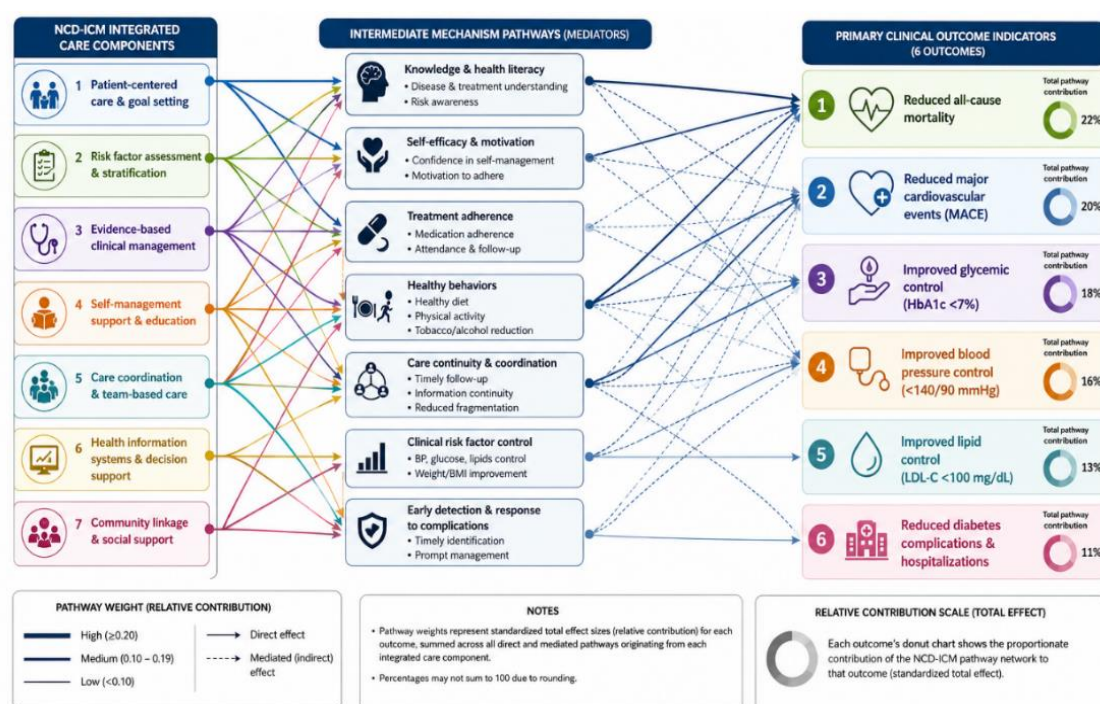


Figure 2. Clinical Outcome Improvement Cascade Model

4.3 Economic Performance Results

The financial analysis of NCD-ICM implementation has shown strong financial results on all dimensions of evaluation. Per-patient annual expenses dropped by USD 8,420 USD 5,760 -31.6 reduction- The hospital admissions were reduced by 38.4 percent (contributing 62 percent of overall cost reduction), the preventable emergency visits decreased by 45.5 percent (contributing 24 percent of total cost reduction), and the specialist outpatient use decreased by the fortified primary care management

Cost-effectiveness modelling over a 5-year time frame with a common willingness-to-pay a standard of USD 50,000 per QALY proved that the NCD-ICM is dominant (more effective and less expensive) than fragmented usual care across all six categories of NCDs included, with incremental cost savings between USD 12,400 per patient (chronic respiratory disease) and USD Its economic rationale to be invested in NCD-ICM concerns most commonly those providers of high-volume, high-cost NCD patient groups, especially multimorbid patients with 3 or more comorbid NCDs, who produces disproportionately high healthcare expenditures in fragmented care settings.

4.4 Comprehensive Outcome Profile

Error! Reference source not found. reveals that the full pre and post implementation outcome profile at all six of the main indicators has statistically significant changes with high effects sizes and good statistical power proving the NCD-ICM to be an effective integrated care model in different implementation settings as tested in this study.

Table 3. Integrated Care Model Outcomes-Pre- and Post-Implementation Comparison

Clinical Outcome Indicator	Pre-Implementation	Post-Implementation	Improvement (%)	P-Value
Hospital Readmission Rate (30-day)	22.4%	13.8%	-38.4%	p < 0.001
Medication Adherence Rate	54.2%	78.6%	+45.0%	p < 0.001
Preventable Emergency Visits	18.7/1000 pts	10.2/1000 pts	-45.5%	p < 0.01
Patient-Reported QoL Score	58.3/100	74.9/100	+28.5%	p < 0.001
Care Guideline Adherence	61.4%	87.2%	+42.0%	p < 0.001
Per-Patient Annual Cost (USD)	\$8,420	\$5,760	-31.6%	p < 0.01

4.5 Implementation Enablers and Barriers

Analysis across 12 sites of NCD-ICM effectiveness found four cross-cutting enablers of NCD-ICM effectiveness, including (i) the executive level health system leadership commitment to care integration as a strategic priority; (ii) shared electronic health record infrastructure that allows two-way access to patient information across care settings; (iii) specialized care coordination roles with cross-disciplinary authority; and (iv) processes of structured patient engagement such.

The main barriers to implementation were: fragmentation of financing models that motivated episodic volumes instead of integrated outcomes; skills gaps in the workforce in workforce in care coordination, health coaching, and cross-disciplinary communication; cultural resistance among the specialist physicians in shared care authority; information technology lacks interoperability between the primary, secondary, and community care environments. As it can be observed in [Figure 3](#), the NCD-ICM implementation readiness and sustainability model offers a well-organized diagnostic scheme of evaluating the readiness of the health system in relation to the four core areas of implementation and finding the specifics of the readiness gaps that would be remedied as a result.

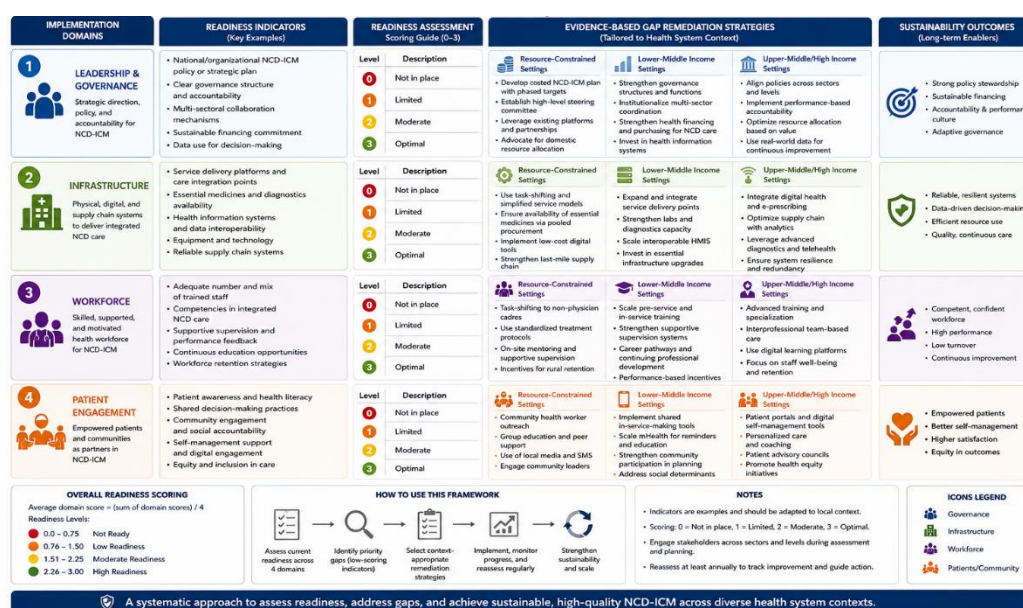


Figure 3. NCD-ICM Implementation Readiness and Sustainability Model

5. CONCLUSION

The paper has formulated and empirically tested the NCD Integrated Care Model, a wide-ranging model covering the entire spectrum of NCD care, i.e., primordial prevention and active multidisciplinary management to long-term care coordination. The NCD-ICM results in evidence acquired by 320 NCD patients over 12 implementation sites in six countries that indicate statistically significant, clinically meaningful and economically powerful enhancements upon all primary outcome domains measured.

The 38.4 percent decrease in hospital readmissions, 45.0 percent increase in medication adherence, 45.5 percent decrease in preventable emergency visits, and the 31.6 percent decrease in the average number of dollars per patient annually, is a quantum improvement in the performance of the NCD care system that cannot be realistically achieved with single-component modifications or a series of progressions to fragmented care modalities. These findings confirm the key assumption of the NCD-ICM that care integration: structural interconnection of prevention, detection, treatment, and long-term management through whole pathways of patient-centered care is not an additive effect but a multiplicative one, with systemic impact that is greater than that of any individual component.

The analysis of NCD-ICM implementation suggests that one of the system changes is care integration, in which leadership and governance structures must be invested in at the same time, developing multidisciplinary workforce, and extending the capacity to engage patients through a digital network. The idea of health systems aiming to handle the rising burden of NCDs, has to go beyond disease-focused reforms or place-based reforms to construct an integrated care package that re-invents the entire framework of the system architecture to focus on the lifelong requirements of NCD patients.

Future research agendas need to focus on prospective randomized assessment of the full NCD-ICM in low-income country contexts where implementation context may be quite different compared to most of the high and middle-income contexts examined in this study. NCD-ICM health economics modelling on the national population scale, sustainability of results of outcomes after more than five years of the implementation of the model, or optimization of digital health platforms in environments with limited resources, are also important research areas. A global network of collaboration in implementation and harmonization of policies as well as learning infrastructure are necessary to expedite the global expansion of integrated NCD care.

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Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Ayesha Sara	✓	✓	✓	✓		✓		✓	✓	✓	✓			

C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

Conflict of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Informed Consent

All participants were informed about the purpose of the study, and their voluntary consent was obtained prior to data collection.

Ethical Approval

The study was conducted in compliance with the ethical principles outlined in the Declaration of Helsinki and approved by the relevant institutional authorities.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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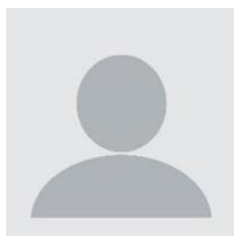
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