



TELEHEALTH IC PROGRAM

**A TRANSDISCIPLINARY
FRAMEWORK FOR EFFECTIVE
AND RELIABLE CONTINUUM OF
CARE**

Authored by

IEEE SA Transforming the Telehealth Paradigm Industry Connections
Program

in collaboration with the

IEEE SA Transdisciplinary Framework for 5G and Future Networks Enabled
Applications and Services Industry Connections

TRADEMARKS AND DISCLAIMERS

IEEE believes the information in this publication is accurate as of its publication date; such information is subject to change without notice. IEEE is not responsible for any inadvertent errors.

The ideas and proposals in this specification are the respective author's views and do not represent the views of the affiliated organization.

ACKNOWLEDGMENTS

Special thanks are given to the following authors of this paper:

Katherine Grace (Kit) August, *IEEE Senior Member*

Elizabeth White Baker, *Virginia Commonwealth University*

Paul Barach, *Thomas Jefferson School of Medicine, USA, Imperial College London, U.K.*

Dimitrios Kalogeropoulos, *Global Health & Digital Innovation Foundation, UCL Global Business School for Health*

Victor B. Lawrence, *IEEE Life Fellow, Stevens Institute of Technology*

Narendra Mangra, *GlobeNet LLC*

Norma A. Padrón, *EmpiricaLab'*

Michael Tremblay, *University of Kent, Canterbury, UK*

The Institute of Electrical and Electronics Engineers, Inc. 3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2024 by The Institute of Electrical and Electronics Engineers, Inc.

All rights reserved. 9 August 2024. Printed in the United States of America.

PDF: STDVA27214 979-8-8557-1080-9

IEEE is a registered trademark in the U. S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated. All other trademarks are the property of the respective trademark owners.

IEEE prohibits discrimination, harassment, and bullying. For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html>.

No part of this publication may be reproduced in any form, in an electronic retrieval system, or otherwise, without the prior written permission of the publisher.

Find IEEE standards and standards-related product listings at: <http://standards.ieee.org>.

NOTICE AND DISCLAIMER OF LIABILITY CONCERNING THE USE OF IEEE SA INDUSTRY CONNECTIONS DOCUMENTS

This IEEE Standards Association (“IEEE SA”) Industry Connections publication (“Work”) is not a consensus standard document. Specifically, this document is NOT AN IEEE STANDARD. Information contained in this Work has been created by, or obtained from, sources believed to be reliable, and reviewed by members of the IEEE SA Industry Connections activity that produced this Work. IEEE and the IEEE SA Industry Connections activity members expressly disclaim all warranties (express, implied, and statutory) related to this Work, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; quality, accuracy, effectiveness, currency, or completeness of the Work or content within the Work. In addition, IEEE and the IEEE SA Industry Connections activity members disclaim any and all conditions relating to: results; and workmanlike effort. This IEEE SA Industry Connections document is supplied “AS IS” and “WITH ALL FAULTS.”

Although the IEEE SA Industry Connections activity members who have created this Work believe that the information and guidance given in this Work serve as an enhancement to users, all persons must rely upon their own skill and judgment when making use of it. IN NO EVENT SHALL IEEE OR IEEE SA INDUSTRY CONNECTIONS ACTIVITY MEMBERS BE LIABLE FOR ANY ERRORS OR OMISSIONS OR DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS WORK, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Further, information contained in this Work may be protected by intellectual property rights held by third parties or organizations, and the use of this information may require the user to negotiate with any such rights holders in order to legally acquire the rights to do so, and such rights holders may refuse to grant such rights. Attention is also called to the possibility that implementation of any or all of this Work may require use of subject matter covered by patent rights. By publication of this Work, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. The IEEE is not responsible for identifying patent rights for which a license may be required, or for conducting inquiries into the legal validity or scope of patents claims. Users are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. No commitment to grant licenses under patent rights on a reasonable or non-discriminatory basis has been sought or received from any rights holder. The policies and procedures under which this document was created can be viewed at <http://standards.ieee.org/about/sasb/iccom/>.

This Work is published with the understanding that IEEE and the ICom members are supplying information through this Work, not attempting to render engineering or other professional services. If such services are required, the assistance of an appropriate professional should be sought. IEEE is not responsible for the statements and opinions advanced in this Work.

TABLE OF CONTENTS

ABSTRACT	5
1. INTRODUCTION TO THE CONTINUUM OF CARE	6
1.1. PREVENTION AND SELF-CARE	8
1.2. COMMUNITY AND PRIMARY CARE	9
1.3. HOSPITALS AND SPECIALIST CARE	9
1.4. REHABILITATION AND RECOVERY CARE	10
1.5. LONG TERM CARE	10
1.6. HOSPICE AND PALLIATIVE CARE	10
1.7. END-OF-LIFE CARE	11
2. HEALTHCARE ECOSYSTEM: A TRANSDISCIPLINARY APPROACH	11
2.1. TELEHEALTH AND CONTINUITY OF CARE	13
2.2. TRANSDISCIPLINARY FRAMEWORK	15
2.2.1. CONCEPTUAL VIEW	15
2.2.2. COMPREHENSIVE ARCHITECTURAL VIEW	16
2.2.3. COLLOCATED MEDICAL TEAMS AND PATIENTS USING AN INDOOR NON-PUBLIC NETWORK (OR PRIVATE NETWORK)	17
2.2.4. NON-COLLOCATED MEDICAL TEAMS AND PATIENTS USING COMBINATIONS OF VPNS, PUBLIC AND NON-PUBLIC NETWORKS	18
2.2.5. DEPLOYMENT VIEW	19
2.2.6. NETWORKS	23
2.2.7. GOVERNANCE	24
2.3. HOW STANDARDS AND TECHNOLOGY CAN EXTRACT VALUE AND DELIVER BENEFITS TO THE CONTINUUM OF CARE	24
2.3.1. METHODICALLY MEASURING CARE OUTCOMES: COLLECTING DATA AND STANDARDIZING RECORDS	24
2.3.2. STRENGTHENING COMMUNICATION, DISSEMINATION, AND FOLLOW-UP	25
2.3.3. ESTABLISHING SUCCESS METRICS AND UNDERSTANDING HOW TO MAKE THESE OUTCOMES BEST-OF-CLASS	25
2.3.4. VALUE	26
2.3.5. SYSTEMATICALLY PREVENTING AVOIDABLE HARM TO PATIENTS	26
2.4. AI AND STANDARDS IN THE CONTINUUM OF CARE	27
3. CONCLUSIONS	31
4. REFERENCES	33

A TRANSDISCIPLINARY FRAMEWORK FOR EFFECTIVE AND RELIABLE CONTINUUM OF CARE

ABSTRACT

Global healthcare systems, with their plurality of structures and management arrangements among several unrelated organizations with various goals, information sources, and payment models, are ill-equipped to handle the complex current environment in which their patients live. External environmental shocks to human health, such as pandemics and climate events, have highlighted the need for effective tools that better identify and address health disparities and call attention to underperformance throughout the healthcare system. A Transdisciplinary Framework for a continuum of care can provide a structured approach that integrates the healthcare ecosystem, networks, technologies, enablers, and governance functions for current and future considerations. It may be customized based on local priorities, capabilities, and constraints to provide effective and reliable services across the continuum of care. The evolving healthcare landscape will likely involve a combination of AI-enhanced community-based care, outpatient services, and traditional hospital care. Healthcare systems will need to adapt and integrate these technologies thoughtfully to ensure a comprehensive and patient-centered approach across the continuum of care.

1. INTRODUCTION TO THE CONTINUUM OF CARE

Technology plays a crucial role in addressing society's most essential needs, such as the goal of providing equitable healthcare for all. Technology innovations are changing our world through many means: pervasive computing, communications and broadband connectivity, satellites, worn sensors, Internet of Things (IoT), smart homes, data fusion, machine learning and artificial intelligence (ML/AI), edge computing, large language models (LLM), digital twins, extended/augmented reality (XR/AR), robotics, telehealth, hospital at home, accessibility, automation and much more. Smart technological innovations using human-centered and sound human factors approaches can significantly improve the quality of life.

Designing and delivering to the continuum of care aims to support citizens' wellness goals as we restore health status, avoid functional decline, promote longevity and healthy aging, and strive to optimize societal resilience.

Continuum of care refers to the practice of providing consistent and coordinated health care for a patient over a period of time and across the spectrum of care. As a person's needs change over time, the continuum of care evolves and will vary based on their changing needs. It should deliver safe care, reduce overall care costs, and optimize health system performance.

In some healthcare systems, healthcare organizations are diverse, with a plurality of structures and management arrangements, and are not necessarily under one management structure. (e.g., not vertically integrated). In such cases, the continuum of care depends on formal or informal connections among several unrelated organizations with various goals, information sources, resources, and payment models. In turn, these organizations may not have a duty to collaborate or coordinate or may need (financial) incentives to collaborate for a common goal involving the patient's healthcare outcomes. Many of these organizations may use the information to limit patient movement to another care provider, as this may have an impact on revenue income or use of resources: for example, a hospital will withhold lab test reports for infection, including C-diff, hepatitis, osteomyelitis, and MRSA, to transfer a patient to a rehabilitation or nursing home facility—as the benefits of such a transfer do not accrue to the transferring provider but the receiving provider. This has further consequences when diagnosis and treatment are delayed or deferred because the patient is no longer in the facility that conducted the testing, as test results are not transferred. A common concern is that the next facility is not providing a level of care for the diagnosis. However, this is hard to verify when providers and health systems sequester patient information.

A key objective for achieving continuity of care is ensuring that information is transparent and associated implications are available to all stakeholders. Patients and their caregivers can rarely access any of the data

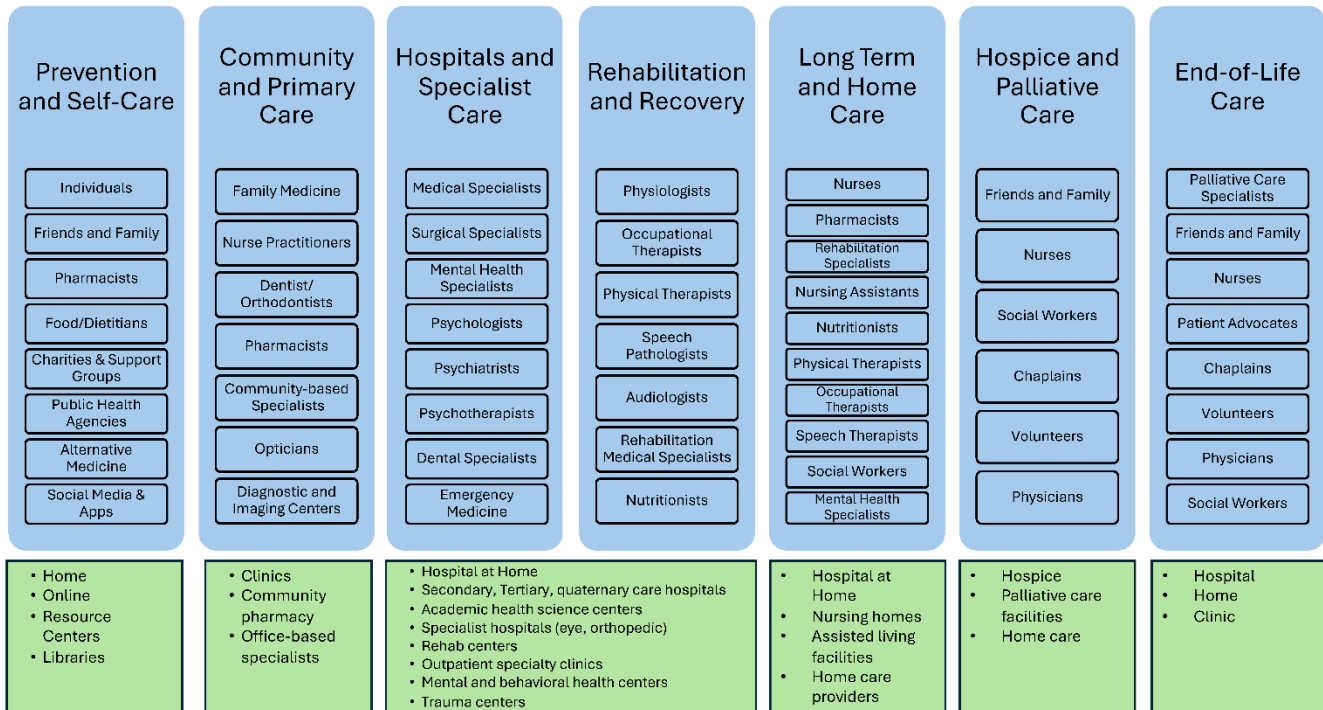
during a care intervention and have no authority to alter, update, or augment any data, for example, the patient's need for durable medical equipment such as a wheelchair, trapeze, or laboratory test results from the current or prior health encounter. In some health systems, records of these tests can only be obtained through a Records Request, which can take several days. Any such delay in test results can fall outside the useful time frame for continuity of care. All information needs to be available across entities, even when a person has moved to another facility or transitioned to a different level of care in varied geographic settings. Digital health autonomy, facilitated by telehealth and digital patient navigation programs, interventions, and tools (Chan, et al. [1], Fitzpatrick [2]),¹ is a pivotal concept empowering patients to engage in information exchange, enhance care continuity processes, endorse data portability, improve the quality of collaborative datasets among providers and for clinical research, and expedite data integration response times as required.

Understanding the continuum of care requires assessing a big-picture overview of medical services. The continuum of care can encompass the changing healthcare needs throughout a patient's life or focus on a particular health condition. The term commonly describes health care that follows patients over a period of time—from preventive care to treatment for medical concerns, rehabilitation, and maintenance. Each type of service complements others throughout the continuum, making treatment more efficient and effective.

A continuum of care endeavors to knit together elements of several functional activities. FIGURE 1 illustrates the basic structure of a generic continuum of care and demonstrates the essential components, professions involved in each element, and the type of organization that might provide services in that component.

¹ Numbers in brackets correspond to references listed in Section 4.

FIGURE 1 Generic Continuum of Care



1.1. PREVENTION AND SELF-CARE

A continuum of care centered on self-care involves disease prevention, health promotion, and public health measures such as population screening and vaccinations. Self-care with patient and/or caregivers supporting and taking on care responsibilities is becoming a critical focus for the continuum of care as advances in treatment increasingly enable self-care (e.g., oral-administered cancer therapies) or novel technologies that support better individual decision-making based on self-monitoring (e.g., wearables).

In addition, screening for a variety of conditions and diseases is an area of opportunity for wellness in a continuum of care. For example, screening for vision, color vision, hearing, neurological conditions, motor conditions, and more should be easy and routine. Screening and early intervention can benefit the individual, family, community, and everybody locally and globally.

1.2. COMMUNITY AND PRIMARY CARE

Abundant evidence demonstrates that strong primary care systems should be the individual's first port of call when some treatment is needed. Over 80% of care system activity sits within this area and includes general medical, dental, and nurse practitioners, physiotherapists, pharmacists, nutritionists, and other resources directly accessible to the individual. This usually includes access to psychotherapies and mental health services. Complementary and alternative care includes chiropractic and osteopathic medicine, Traditional Chinese Medicine, and Ayurvedic medicine in India, each formally established in these countries' care systems.

From a quality and effectiveness perspective, primary care is the “gatekeeper” for referrals to more specialist care providers in the highest-ranked health systems. In other, more costly systems, individuals have direct access to specialists, who could be seen as functioning in a primary care way or by avoiding potential hospital access. Once a person is diagnosed, care is usually managed by these providers. These people are invariably located in the local community, easily accessible by public transport, and have connections to community support groups and services. Generally, this accounts for about 14% of expenditure within healthcare systems (OECD [3]).

1.3. HOSPITALS AND SPECIALIST CARE

Hospitals exist as an organizational arrangement for co-locating a mix of expertise to ensure easy and speedy access to diagnosis and treatment. Hospitals and specialist care focus on diagnosis and treatment that cannot be done within the community and primary care. While the most familiar medical professions are here, such as surgeons, cardiologists, or oncologists, it also includes specialist therapies (audiology, speech pathology, physiotherapy, occupational therapy) and specialist diagnostic and treatment support (imaging and laboratories), a great many of which do not need to be co-located in hospitals. Many specialists focus on very complex conditions (super specialists). These are found in tertiary or quaternary hospitals and academic health science centers, not community or secondary care hospitals.

As medical technologies evolve, this can change, leading to the “unbundling” of hospitals and specialists' services toward the community setting (Tremblay and Walsh [4]). Examples include shifting from inpatient elective care to day case care to achieve same-day discharge, cataract surgery, and hernia repair. For instance, society can only speculate how robotic surgery, stereotactic radiosurgery, or theranostics may unbundle monolithic treatment models.

1.4. REHABILITATION AND RECOVERY CARE

A separate area of the care continuum focuses on what follows specialist care or hospitalization. This is where individuals receive rehabilitation to restore function and other support for “activities of daily living.” An example is cardiac rehabilitation, which should ideally follow immediate hospital discharge after a heart attack. It is its own continuum of care with diet management, weight control, and physical activity, often in a community setting.

Complex rehabilitation for head injuries, for instance, involves occupational therapy and psychologists for cognitive behavioral therapy, and stroke rehabilitation needs specialists in swallowing disorders.

Physiatry and ongoing rehabilitation for people with paralysis, hemiparesis, mobility, and other issues will continue and, at times, restore function and prevent loss of function. Currently, many parameters must be met for patients to qualify for specific therapies; with the continuum of care of the future, including telemedicine and digital presence, many more people can benefit from these essential rehabilitation therapies.

1.5. LONG-TERM CARE

For long-term conditions, where there is a loss of physical function (frailty), there is a range of settings, from the home to specialist nursing resources, to support maintaining independence for as long as possible. However, life expectancy in nursing homes averages about two years. Apart from those results, the options are hospice or palliative care (ONS [5]), but they also vary by the individual’s age.

1.6. HOSPICE AND PALLIATIVE CARE

This focus is on providing emotional and physical support and comfort and often pain relief for individuals with severe and life-ending conditions. New models in hospice care include treatment for the condition in addition to emotional and physical support and comfort in pain relief. Over the past few years, Medicare has demonstrated success in providing care at the same time as hospice, with improved outcomes for many people who live a longer and better quality of life.

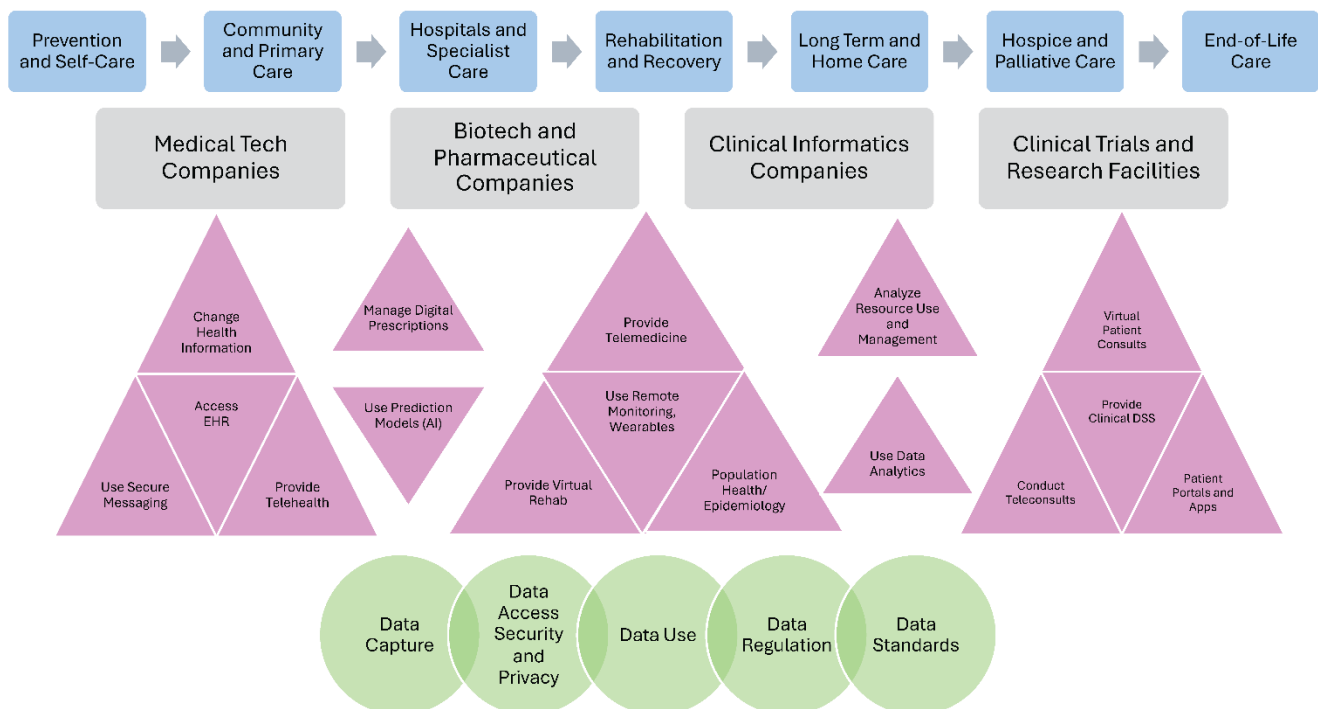
1.7. END-OF-LIFE CARE

End-of-life care/hospice care focuses on a person's quality of life as they near the end of life. A team of healthcare professionals works together to manage symptoms, distress, spiritual issues, and arrangements for the end of life. In most countries, this includes do-not-resuscitate orders and living wills and, in a few, providers of euthanasia (assisted dying) and non-resuscitation.

2. HEALTHCARE ECOSYSTEM: A TRANSDISCIPLINARY APPROACH

Describing the continuum of care and its components identifies the ecosystem within which health professionals, clinical managers, and care providers operate. FIGURE 2 illustrates the overall structure typical of most healthcare systems, but countries or professions will vary due to their differing regulatory systems and clinical practices.

FIGURE 2 The information value chain within the generic continuum of care



The goal should be to create “scalable modularity” to help ensure that the ecosystem can dynamically adjust to the changing risks, requirements, and locations of care of patients and their caregivers.

Challenging examples include dealing with emergencies on airplanes or ships, establishing temporary health infrastructures to deal with refugee camps or large-scale migration from conflict zones, evolving needs to support recovery in post-conflict zones (wars, civil unrest) and settings with specific requirements such as the military (e.g., managing combat and pilot fatigue, battlefield injuries) and prisons (e.g., psychological counseling, and mental health).

Several diverse, complex aspects require an alignment for effective continuum of care solutions to achieve these goals. They include building trusting patient and provider relationships, enabling informal care, bridging the digital divide through connectivity and accessibility, healthcare inclusion to mitigate the effects of social and economic inequalities, coordination of services across sectors, accountability, governance, UN SDGs, and so on. Furthermore, there are better models than a one-size-fits-all model for the continuum of care, especially for disadvantaged groups. The map below (FIGURE 3) demonstrates the conceptual approach for global telehealth services with healthcare delivery points, mobile penetration rates, and densely populated city centers. Generally, urban areas tend to have higher availability of healthcare delivery points and wireless and wireline communication networks. This creates opportunities to provide telehealth services to extend healthcare services to marginalized areas and deepen the level of new and existing healthcare services through a combination of synchronous and asynchronous care across geographies.

FIGURE 3 The Conceptual Approach for Global Telehealth Services

