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Global Status of Infrastructure and Opportunities for eHealth: Implications for Kidney Care Delivery in Low-income and Lower-Middle-Income Countries

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Abstract

Objective:

To describe the regional status of digital services for kidney care across eight eHealth themes: eHealth foundations, mobile health (mHealth), telehealth, eLearning, electronic health records, legal frameworks for eHealth, social media and big data.

Design, setting and participants:

We used data from the World Health Organization (WHO) third global survey on eHealth, as well as data from the World Bank, and Internet World Stats on global digital services. Data were recategorized by International Society of Nephrology (ISN) regions and presented descriptively.

Outcome measures:

The availability of digital services and governance frameworks for kidney care across ISN regions.

Results:

The survey conducted by the WHO received responses from 125 (64.4%) Member States representing 4.4 billion people globally. The number of mobile cellular subscriptions were < 100% of the population in Africa, South Asia, North America, and North East Asia; percentage of internet users increased from 2015 to 2020 in all regions. Western Europe had the highest percentage of internet users in all the periods: 2015 (82.0%), 2019 (90.7%), and 2020 (93.9%); Africa had the least: 9.8%, 21.8% and 31.4%, respectively. The North East Asia region had the highest availability of national electronic health record system (75%) and eLearning access in medical schools (100%) with the lowest in Africa (27% and 39%, respectively). Policies concerning governance aspects of eHealth (e.g. privacy, liability, data sharing) were more widely available in high-income countries (55% to 93%) than in low-income countries (0% to 47%) while access to mHealth for treatment adherence was more available in low-income countries (21%) than in high-income countries (7%).

Conclusion:

The penetration of eHealth services across ISN regions is suboptimal, particularly in low-income countries. Increasing utilization of internet communication technologies provides an opportunity to improve access to kidney education and care globally, especially in low-income countries.

Strengths and Limitations of this study:

- This study identified gaps in eHealth services available for kidney care across countries and regions of the International Society of Nephrology (ISN).
- We highlighted the increasing availability of mobile / cellular subscriptions and the number of internet users observed in various countries from 2015 to 2020, especially those in low-income groups.
- The study also highlights the lack of policy and governance strategies relevant to eHealth (e.g. privacy, liability, data sharing / ownership), as well as poor utilization of eHealth for learning and health information systems.
- Although workforce shortages for learning, training and delivery of kidney care are more pronounced in low resource settings than in high-income countries, we emphasized that this can be substantially mitigated by leveraging the increasing availability of electronic platforms to improve kidney health.
- A limitation of this work may relate to the non-participation in the survey used for our study of a few countries with large populations in their regions.

Introduction:

Approximately 97% of people worldwide live within reach of a mobile cellular signal.[1] The widespread availability of this service can be a platform for increased utilization of registries, electronic health records and diseases surveillance systems to empower monitoring and reporting of disease incidence and prevalence,[2] patient outcomes,[3] and quality and safety of delivered care[3,4] as well as to allow comparison between and within health services.[5-7] eHealth is the cost-effective and secure use of information and communications technologies (ICT) in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research.[8] According to the World Health Organization (WHO), 87% of Member States have one or more national mHealth initiatives, 58% have an effective strategy for eHealth, 55% have legislation to protect electronic patient data.[8]

In the current era of the COVID-19 global pandemic, the potential for using eHealth to transform kidney disease management is increasingly recognized.[9,10] A cross-sectional survey conducted by the International Society of Nephrology (ISN) Global Kidney Health Atlas (GKHA) in 2017 reported low utilization of health information systems (HIS) in the care of patients with kidney failure, especially in low-income countries (LICs) and lower-middle-income countries (LMICs).[11] However, the survey was limited by a focus on registries.[11] Furthermore, a systematic review of 43 studies that included 6,617 participants and evaluated the impact of an eHealth intervention in people with CKD did not find sufficient value for eHealth in patients with CKD although eHealth was suggested to be useful for dietary sodium intake and fluid management.[12] However, other studies have shown that some forms of eHealth (e.g. telenephrology) are useful for improving access to kidney care in primary care settings,[13] for self-management for patients with CKD,[14] for nurse

practitioner and nephrologist training and education,[15,16] and for safe, economical and efficient care delivery in rural and remote areas.[17] The current manuscript describes the status of eHealth services and eHealth governance across ISN regions, using data from the World Health Organization (WHO) third global survey on eHealth.[18] We also appraise the implications of our findings for kidney care across ISN regions.

Methods

We leveraged published data from the WHO third global survey on eHealth.[18] The survey methodology is summarized as follows. The survey was developed and conducted by the WHO through the Global Observatory for eHealth (GOe) with input and consultation from experts in digital health. The survey assessed eight themes in eHealth including: (i) eHealth foundations, (ii) mobile health (mHealth), (iii) telehealth, (iv) eLearning, (v) electronic health records (EHR), (vi) legal frameworks for eHealth, (vii) social media and (viii) big data. Concise definitions of these themes are provided:

- **eHealth:**[19] the cost-effective and secure use of information communication technologies (ICT) in support of health and health related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research.
- **mHealth:**[18] the use of mobile devices, such as mobile phones, patient monitoring devices, Personal Digital Assistants (PDAs), and wireless devices, for medical and public health practice.
- **Telehealth:**[18] the delivery of health care services through ICT for the exchange of information in real time (synchronously) or by store-and-forward methods (asynchronously) for the diagnosis and treatment of diseases and injuries, research

and evaluation, and for the continuing education of health professionals where patients and care providers are separated by distance.

- **eLearning:**[20] the use of ICT for education
- **Electronic Health Records (EHR):**[18] real-time, patient-centred records that provide immediate and secure information to authorized users and typically contain a patient's medical history, diagnoses and treatment, medications, allergies, immunizations, as well as radiology images and laboratory results.
- **Legal framework for eHealth:**[18] the legislative process addressing transfer and use of information between health care workers and patients that is relevant to issues of privacy and confidentiality of patient data, access rights and sharing rights for data, addressing data quality and integrity as a basis for clinical and patient decision-making and rules governing the adaptation of professional liability to accommodate care provided remotely or virtually.
- **Social Media:**[18] interactive platforms for individuals, communities and organizations to share and discuss content, debate issues and promote new ideas e.g. Facebook, Twitter or YouTube.
- **Big data:**[18] refers to extremely large data sets that encompass a range of data including clinical data from electronic health records; the phenotype; genomic information; and data on other determinants of health such as environment and lifestyle.

The survey was developed in English and translated into seven languages (Arabic, Chinese, English, French, Russian, Spanish and Portuguese) to improve country responses and accuracy of responses. A web-based tool, (LimeSurvey - https://www.limesurvey.org/en/), was used for online form creation, data collection and

management. WHO regional offices staff assisted in coordinating the survey process and liaising with the GOe Secretariat in Geneva. National level survey coordinators, together with relevant ministries and academic and research institutions identified between 5 and 10 national expert informant groups in eHealth to participate in the survey. The group consisted of eHealth specialists, professionals in telehealth, EHRs, mHealth and statisticians responsible for national health data. Expert informants met for one day to reach consensus on a single national-level response. Hence, each participating country submitted a single national survey with input from its group of expert informants. The survey was conducted between 1 April and 30 June 2015. Data on information and communication technology (ICT) indices were obtained from the World Bank[21] while more recent (2019 and 2020) data on internet usage were obtained from Internet World Stats (https://www.internetworldstats.com/).

Data handling and processing

After receiving the completed questionnaires, all non-English responses were translated into English and survey responses were checked for consistency. Data were then analyzed by thematic sections using computed percentages for each "yes" response to obtain the overall results for all responding countries and regions. We regrouped country responses using the ten ISN regional classification: Africa, East and Central Europe, Latin America, Middle East, Newly Independent States (NIS) and Russia, North America and Caribbean, North and East Asia, Oceania and South East Asia (OSEA), South Asia and Western Europe (https://www.theisn.org/about-isn/governance/regional-boards/). Country responses were also grouped according to World Bank income groups. Data on mobile-cellular subscriptions and internet users in each region were provided as the median percentage of the total population of participating regions. No statistical comparisons were used for describing the data which were presented in percentages.

Patient and public involvement:

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Results

(i) Participating country indices

A response to the survey was received from 125 WHO Member States out of 194 Member States that were surveyed, representing a response rate of 64.4% and a total population of 4.39 billion people. The list of participating countries based on ISN reginal groups is presented in Supplementary Table S1 and a summary of the demographic, economic and health metrics for each region is shown in Table 1. Overall, the median ICT development index for participating countries was 4.8 (95% CI: 2.9-6.9). Four regions: Africa (2.3), South Asia (2.3), OSEA (4.0) and Latin America (4.4) had lower indices compared to the median value while Western Europe had the highest (7.9). Subscriptions to mobile-cellular networks was highest in the Latin America region (124.6% [95% CI: 89.9 – 142.7]) and lowest in South Asia (71.3% [95% CI: 63.7 – 120.6]) while percentage of the population that used the internet was highest in Western Europe (82.0% [95% CI: 70.0 – 93.0]) and lowest in Africa (9.8% [95% CI: 3.0 – 18.1]) (Figure 1). However, internet users increased across all regions in 2019 and 2020, including Africa (21.8% and 31.4%, respectively) and South Asia (34% and 46%, respectively) (Figure 1).

(ii) National eHealth policies, funding and capacity building

A national policy for eHealth was available in all participating countries in North America (100%) and North East Asia (100%) and was lowest in participating countries from

Africa (42%) and East and Central European countries (47%) (Figure S1). Availability of policies governing health information systems (HIS) in countries across regions also varied across regions. Overall, participating countries reported multiple sources of funding for eHealth including public (77%), donor (non-public) (63%), private (commercial) (40%) and public-private partnerships (42%) and LICs and LMICs relied more on donor funding for eHealth services (Figure S2). Overall, pre-service, and in-service training in eHealth were available in 74% and 77%, respectively. Pre-service training was lowest in Africa (55%) and highest in NIS and Russia (100%) and North America (100%). In-service training was lowest in Africa (58%) and highest in North and East Asia (100%) (Figure S3).

(iii) mHealth

Data on access to mHealth across 3 of the 6 domains reported (toll-free emergency, appointment reminders and treatment adherence) are provided in Supplementary Table S2. International toll-free emergency access to mHealth was available in only 2 regions: OSEA (10%) and Western Europe (11%) and was unavailable in all regions for appointment reminders. National toll-free emergency access to mHealth services was variably available in all regions. Access to National mHealth services for treatment adherence was mostly available in low-income countries (21%) and was lowest in high-income countries (HICs) (7%).

(iv) Telehealth

Teledermatology, telepathology, teleradiology and telepsychiatry were reported but telenephrology programs were not reported. Nonetheless, services for remote patient monitoring were mostly available in HICs (40%) and at the local / peripheral health care system level with the program fully established only in 26% of countries (Table 2).

(v) eLearning in health sciences

The availability of eLearning for health sciences students (pre-service) and health professionals (in-service) in Medicine (Medical School), nursing and midwifery and pharmacy are reported in Figure S4. Use of eLearning in Medical school was highest in North East Asia (100%) and lowest in South Asia (40%) and Africa (39%). North East Asia also had the highest use of eLearning services for pre-service training of nurses and midwives (75%) and pharmacists (100%). Use of eLearning for pharmacists training was unavailable in South Asia (Figure S4).

(vi) Electronic health records (EHR) systems

National EHR systems were mostly available in in North East Asia (75%) while countries in Africa had the least availability of EHR systems (27%) (Figure 2A). Overall, secondary healthcare facilities were more likely to have EHR systems (42%) than primary healthcare (41%) or tertiary healthcare facilities (39%) (Figure S5). Secondary and tertiary facilities in the NIS and Russia region had the highest availability of EHR systems (73% and 64%, respectively) while all tiers of healthcare facilities in Africa had the lowest (Figure S5). Availability of laboratory information systems, pathology information systems, picture archiving and communication system (PACS) and pharmacy information systems by income groups are shown in Figures 2B-2E with most regions reporting low availability of these systems for healthcare. Human resource availability for HIS was similar across income groups but was highest in the Oceania and the South East Asia region (80%) (Figure S6).

(vii) Legal frameworks for eHealth

Aspects of the legal framework governing use of eHealth were not readily available across countries and regions (Figure S7). For instance, countries from the South Asia region, did not have frameworks governing liability or reimbursement for eHealth, patient safety and quality of care based on data quality, protection of the privacy of individuals, sharing of digital data between health professionals and sharing of personal health data between research entities (Figure S7).

(viii) Social media

National policy on use of social media by government organizations was lacking and ranged from as low as 9% in the NIS and Russia region to 50% in the North East Asia region. However, specific policy on the use of social media in the health domain was unavailable in six regions (Eastern and Central Europe, Latin America, Middle East, NIS & Russia, North America and South Asia). When utilized, social media were mostly used for making emergency announcements, general health announcements and for health promotion campaigns (Figure S8).

(ix) Big data

Information on policy or strategies that govern use of big data in the health sector and private companies was sparsely reported. In the health sector, 75% of countries in North East Asia had such policies in place (Figure S9).

Discussion

The United Nations Sustainable Development Goals emphasizes the great potential of the spread of information and communications technology and global interconnectedness to accelerate human progress, and to bridge the digital divide to develop knowledge in

societies.[22] The ISN-GKHA has identified large and varied gaps in resources and workforce required for adequate provision of kidney care across several countries, particularly in LICs and LMICs in all the ISN regions. eHealth services may be potential vehicle to harness local resources for improvements in kidney care. This study, which mainly analyzed WHO eHealth survey data using the ISN regional groups, found low ICT development indices mostly in LIC and LMICs, low availability of national EHR and proportion of national eHealth policies in LICs and LMICs, increased utilization of mHealth services in low-income settings, lack of use of eLearning across regions and absence of legal frameworks governing use of eHealth in several ISN regions. These findings underscore the need for concerted action if eHealth is to achieve its potential for reducing inequities in kidney care across regions and countries.

A major challenge in accessing kidney care in many countries is the lack of skilled workforce, specifically the absence of an adequate number of nephrologists.[23] The nephrologist density in HICs in North America and Western Europe is more than 90 times that in low-income countries in Africa, South Asia and Oceania region (28.52 per million population [pmp] vs. 0.31 pmp),[24] suggesting a clear disadvantage in care access for populations with low nephrologist densities.[25] In a global survey Lunney et al identified geography and low nephrology workforce to be associated with lack of access to kidney care, especially in low-income countries.[26] Low nephrology workforce, particularly in rural or remote areas often means long travel distance to access care[27] with potentially negative consequences, including increased cost of care, low quality of life,[28] lack of access to kidney replacement therapies (KRT; i.e. dialysis and transplantation)[28-30] and increased likelihood of death.[31] In a large South African Province with only 2 public service nephrologists, a study that assessed the predictors of mortality in rural dwelling patients receiving KRT at a district hospital, found mortality to be higher in PD patients (P<0.001) who travelled farther to reach

the hospital than those treated with HD.[29] These challenges are not limited to low resource countries, however. One study from Australia estimated that use of telehealth services for evaluating post-transplant patients resulted in a net saving of 203,202 kilometres in patient travel distance; 2771 hours in car travel time; about AUD $31,048 in petrol savings and 51 tonnes CO_2 equivalents of greenhouse gas emissions.[27] Due to the widespread availability of mobile cellular signals,[1] cellular and internet technologies have potential to improve access to nephrology care in remote and/or underserved settings. Access to care can also be improved in children with kidney diseases given the significant shortage of paediatric nephrologists[32] and mitigate high mortality identified in children with kidney failure in regions such as Africa.[33] The global COVID-19 pandemic demonstrates that use of eHealth technologies will likely increase over the coming years,[34,35] thereby highlighting the need to strengthen governance on how eHealth systems are utilized across ISN regions. Care of patients with CKD has been grossly affected during the pandemic, and it falls upon the stakeholder community to develop sustainable solutions.

The prevalence of CKD risk factors such as hypertension and diabetes mellitus continue to increase globally. The rise is projected to be significant, especially in LICs and LMICs of South and South East Asia and Africa.[36,37] For instance, globally, 79% of people with diabetes live in LICs or LMICs (mostly Oceania, South and South East Asia region) and projections of diabetes prevalence by 2045 suggest an increase of 143% in Africa, 96% in the Middle East and 74% in South East Asia compared with 15% and 33% increase in Europe and North America, respectively.[36] Innovative models of care delivery are therefore needed to manage the growing disease burden. Given the wide coverage of mobile phone networks, mHealth holds promise as an important delivery tool for health care delivery in resource constrained regions (Figure 1). mHealth interventions are in use for diagnosis and

management of various infectious diseases including malaria,[38] tuberculosis,[39] and HIV[40] and for improving maternal and foetal health[41] in several developing countries. Although mHealth interventions are increasingly used for non-communicable diseases,[42-44] some studies highlight only a modest impact in NCD control likely due to limited number of studies and impact on process of care alone.[45,46] Our analysis showed that use of mHealth (appointment reminders and treatment adherence) and telehealth services (remote patient monitoring) were much higher in LICs and LMICs than in HICs (Supplementary Table S2 and Table 2). In a study conducted in a rural Indonesian population multifaceted mobile technology–supported primary health care intervention was associated with greater use of preventive CVD medication and lower BP levels among high-risk individuals.[47] These findings suggest that despite the relatively low current use, mHealth may be potentially useful for supporting case-finding for CKD,[48] CKD-specific education to improve awareness, integrated care delivery and efficient referral pathways, and perhaps allow quality control through real-time monitoring.[49]

To guide implementation, ethical issues including type and quality of digital technology, doctor-patient relationship, data confidentiality and security, informed consent and patients and families satisfaction with telemedicine services should be considered in framing legal governance for eHealth.[50] Increasing the use of such technologies will require demonstration of public benefits (e.g. cost saving),[51] while ensuring that there is no discrimination or digital inequality (e.g. not tailored to only those with a smartphone or for the disabled)[52] and to protect patient and data privacy.[53] As our study shows, the legal frameworks that govern sharing of personal health data or digital data and protect the privacy of individual health-related data were either low or absent in many regions. There is need to address such legislation in all regions (Figure S7).

Our study also identified EHR use to be low in LICs and LMICs with poor utilization of eLearning for pre-and in-service training in the health sectors (Figure S5). Barriers that impede adoption and/or implementation of EHR systems such as cost (including setting up, maintenance and ongoing costs), technical concerns, technical support, resistance to changing work habits, loss of income and loss of productivity will need to be identified in each setting and addressed. As Kruse et al[54] have suggested, policy makers will need to consider incentives that reduce the implementation cost of EHR, possibly aimed more directly at organizations that are known to have lower adoption rates, such as small hospitals in rural areas. However, this may be possible in HICs where such technologies are readily available, whereas in LICs and LMICs, such incentives should be targeted towards secondary and tertiary care centres that serve a wider population. Measures that ensure successful adoption and implementation of EHR technology including systems usability, interoperability, and adaptability need to be considered in terms of local context, individual end-users and advancing technology.[55]

The potential and value of eLearning in addressing workforce shortages[20,56] and the educational needs of health professionals, especially in developing countries is well recognized.[57] The ISN fellowship program recently included hybrid (online plus hands-on) training as part of the strategy for improving training of nephrologists from low-resource settings.[23] This can improve training in glomerular diseases (histopathology), assessment of urine microscopic findings as well as various aspects of interventional nephrology including dialysis catheter insertion and care. A number of groups have used virtual platforms to upskill healthcare workers in the care of patients with COVID-19 in India and Africa.[58] Access to the basic IT infrastructure (e.g. computers and internet) remains a major hurdle to the

implementation of technology-enhanced teaching in developing countries.[57] Any solution should be sensitive to local resources and be designed to operate at low cost (data, device). One study that assessed the awareness, attitudes, preferences, and challenges to eLearning among medical and nursing students at Makerere University, Uganda identified low monthly income, quality of internet connectivity and lack of computer ownership among factors that significantly affected attitudes towards eLearning.[59] Perceived advantages of online learning by medical students in the UK included time and money saved from lack of travel and flexibility and ability to learn at one's own pace whereas family distractions, internet connection and the timing of tutorials were identified as barriers.[60] The extent of integration of eLearning in health sciences (Medicine, Nursing and midwifery and Pharmacy) for both pre- and in-service training was low in most regions in our study (Figure S4). The impact of an improved integration of eLearning in health sciences will be widespread across all medical disciplines.

There were a few limitations to this study previously described in the WHO report.[18] These include that WHO Member States were limited to one response per country i.e. expert informants were required to propose a consensus response for each question which was difficult in cases where the situation varied widely within the country. Also, although every effort was made to select the best national experts to complete the instrument; the knowledge capacity of each focus group to accurately answer the questions was not determined. Finally, some countries with large populations (e.g. France, Germany, Brazil, Egypt, Nigeria and India) did not participate in the 2015 survey. This is likely to have affected some of the results of this survey e.g. proportion with access to the internet. Despite the limitations, this study is the first to present a comprehensive overview of the status and penetration of eHealth in ISN regions using data from the WHO global survey on eHealth. Our study has also been

able to address identified gaps in availability of eHealth services and the implications of these for kidney care across ISN regions, particularly for LICs and LMICs.

Conclusion:

There is wide variation in the availability and accessibility of eHealth services across ISN regions with much reduced availability and access in LICs and LMICs. This is likely to have a significant negative impact for adequate kidney care provision in these regions, especially at a time when there are global restrictions in face-to-face contacts. Even though much infrastructure is required to set up such services, simple steps can be initiated towards broader use of eHealth services to aid care including legislations and provision of national guidelines / requirements on use of these technologies. Infrastructure development to improve access to the internet will need to be improved across regions especially in low-income countries. With rapidly evolving ICT technologies and as digitalization of medical education and care continues to gather pace in the future of healthcare, further research on the impact of eHealth in care of patients with kidney diseases is critical. The development of and access to appropriate technologies which facilitate equitable and high-quality care are needed to ensure no one is left behind.

Contributors: AKB conceptualized the research; SM, DZ and SS collated and checked the data for accuracy and completeness; FY analyzed the data; IGO designed the figures and Tables and wrote the first draft of the manuscript. All authors provided inputs for the interpretation of results and documentation of implications of the study findings in the discussion. All authors contributed to the preparation of the final version of the manuscript.

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FIGURE LEGENDS

Figure 1: Proportion of mobile-cellular users and internet access across ISN regions

Figure 2(A – E): (A) Availability of national EHR system, (B - E) Availability of other electronic health record systems (laboratory information systems, pathology information systems, PACS systems, and pharmacy information systems)
Abbreviations: EHR – electronic health records, PACS - picture archiving and communication system)

Supplementary Materials:

Table S1: List of participating countries by ISN regions

Table S2: mHealth for accessing services

Figure S1: National eHealth policies / strategies across ISN regions

Figure S2: Funding sources for eHealth by income groups

Figure S3: eHealth capacity building

Figure S4: Use of e-learning in health sciences across ISN regions

Figure S5: Health facilities with EHR in ISN regions

Figure S6: Availability of human resources for Health Information Systems (HIS)

Figure S7: Legal framework for eHealth across income groups

Figure S8: Health care organizations use of social media across ISN regions

Figure S9: Policy / strategy governing the use of big data

Table 1: Features of participating countries ranked according to ISN regions and World Bank groups

	Total population of participating countries (millions)*	GNI per capita (PPP Int $) *	Physician density (per 10,000 population)	Nurse & midwife density (per 10,000 population)	Hospital bed density (per 10,000 population)	Life expectancy at birth (years)	Total health expenditure (% GDP)	ICT Development Index**
Overall (n=125)	4,389.9	18220 (18722)	1.63 (0.31-3.24)	2.53 (0.74-6.11)	28 (13-49)	74 (66-78)	6.7 (5.4-8.9)	4.8 (2.9-6.9)
ISN regions:								
-Africa (n=33)	600.7	4873 (6190)	0.11 (0.06-0.29)	0.68 (0.42-0.91)	13 (5-20)	60 (57-64)	5.7 (4.4-7.1)	2.3 (1.6-3.7)
-Eastern & Central Europe (n=17)	197.2	18943 (6815)	2.39 (2.02-3.38)	5.50 (4.16-6.27)	54 (39-66)	75 (74-77)	7.2 (5.9-8.0)	6.4 (5.8-6.9)
-Latin America & the Caribbean (n=14)	330.6	12952 (5452)	1.48 (1.11-2.10)	1.04 (0.62-1.51)	14 (10-21)	77 (74-78)	7.3 (6.4-8.8)	4.4 (3.6-6.0)
-Middle East (n=8)	152.3	38863 (40229)	1.95 (0.91-2.88)	2.72 (1.87-5.38)	18 (14-18)	76 (74-78)	5.1 (3.0-7.0)	5.9 (4.7-6.8)
-NIS & Russia (n=11)	278.4	11351 (7072)	3.47 (2.53-3.93)	7.11 (5.02-9.04)	52 (40-87)	69 (69-72)	6.1 (4.5-6.8)	5.3 (5.2-6.4)
-North America (n=4)	359.4	32815 (19823)	1.63 (0.79-2.26)	6.42 (2.33-9.55)	28 (23-31)	77 (73-81)	8.4 (5.7-14.0)	6.6 (4.9-7.9)
-North and East Asia (n=4)	1,548.2	19430 (15835)	2.57 (1.90-3.06)	3.87 (2.64-7.80)	95 (50-135)	73 (69-80)	6.0 (5.6-10.3)	4.8 (4.5-8.3)
-Oceania & South East Asia (n=10)	276.2	20210 (24142)	1.17 (0.18-1.95)	3.50 (1.11-6.00)	23 (14-31)	74 (67-82)	5.3 (4.0-9.4)	4.0 (2.8-7.9)
-South Asia (n=5)	370.4	5366 (3238)	0.36 (0.27-0.83)	0.57 (0.50-0.98)	6 (4-18)	68 (66-71)	3.7 (3.6-8.1)	2.3 (2.2-3.1)
-Western Europe (n=19)	276.6	40262 (11395)	3.49 (3.15-4.10)	8.80 (4.96-15.20)	46 (33-56)	81 (81-82)	9.4 (8.9-10.6)	7.9 (7.5-8.5)
World Bank Groups:								
-Low income (n=19)	353.6	1390 (429)	0.07 (0.04-0.12)	0.53 (0.26-0.77)	10 (4-17)	59 (56-62)	6.2 (4.8-8.1)	1.6 (1.3-1.9)
-Lower-middle income (n=30)	899.9	4816 (2102)	0.38 (0.17-1.60)	0.90 (0.62-3.71)	14 (7-31)	69 (64-72)	5.8 (4.2-6.9)	3.1 (2.4-4.0)
-Upper-middle income (n=34)	2,200.5	14547 (4236)	1.49 (1.15-2.56)	3.28 (1.41-5.41)	27 (17-54)	74 (72-76)	6.3 (5.4-7.2)	4.7 (4.4-5.9)
-High income (n=42)	936.0	38213 (19296)	3.27 (2.43-3.78)	6.27 (4.46-10.86)	38 (32-56)	81 (77-82)	8.9 (6.7-9.7)	7.5 (6.8-8.1)

* - data expressed as mean (SD); all other data represent median and interquartile ranges (IQR)
§ - (per 10,000 population)
** - Data from the World Bank (2015)
GNI – gross national income; PPP – purchasing power parity; GDP – gross domestic product; ICT – Information and communications technology

Table 2: Remote patient monitoring [n (%)]

	Health system level						Programme type			
	International	Regional	National	Intermediate	Local or peripheral level	No response	Informal	Pilot	Established	No response
Overall (n=125)	4(3)	4(3)	19(15)	21(17)	28(22)	65(52)	12(10)	38(30)	15(12)	67(54)
ISN regions:										
-Africa (n=33)	2(6)	0(0)	3(9)	2(6)	4(12)	25(76)	2(6)	5(15)	1(3)	25(76)
-Eastern & Central Europe (n=17)	1(6)	1(6)	3(18)	2(12)	5(29)	6(35)	2(12)	9(53)	0(0)	6(35)
-Latin America & the Caribbean (n=14)	0(0)	0(0)	1(7)	1(7)	4(29)	9(64)	1(7)	4(29)	1(7)	9(64)
-Middle East (n=8)	0(0)	0(0)	0(0)	2(25)	1(13)	5(63)	1(13)	1(13)	1(13)	5(63)
-NIS & Russia (n=11)	0(0)	1(9)	2(18)	3(27)	2(18)	5(45)	3(27)	3(27)	1(9)	5(45)
-North America (n=4)	0(0)	0(0)	0(0)	2(50)	1(25)	2(50)	0(0)	1(25)	1(25)	3(75)
-North and East Asia (n=4)	0(0)	0(0)	2(50)	0(0)	1(25)	1(25)	0(0)	1(25)	1(25)	2(50)
-Oceania & South East Asia (n=10)	0(0)	0(0)	0(0)	0(0)	3(30)	7(70)	0(0)	3(30)	0(0)	7(70)
-South Asia (n=5)	1(20)	0(0)	1(20)	1(20)	0(0)	2(40)	0(0)	2(40)	1(20)	2(40)
-Western Europe (n=19)	0(0)	2(11)	7(37)	8(42)	7(37)	3(16)	3(16)	9(47)	8(42)	3(16)
World Bank Groups:										
-Low income (n=19)	0(0)	0(0)	3(16)	1(5)	2(11)	13(68)	1(5)	3(16)	1(5)	14(74)
-Lower-middle income (n=30)	2(7)	1(3)	3(10)	3(10)	3(10)	21(70)	3(10)	6(20)	1(3)	21(70)
-Upper-middle income (n=34)	0(0)	0(0)	3(9)	4(12)	6(18)	22(65)	2(6)	9(26)	2(6)	22(65)
-High income (n=42)	2(5)	3(7)	10(24)	13(31)	17(40)	9(21)	6(14)	20(48)	11(26)	10(24)

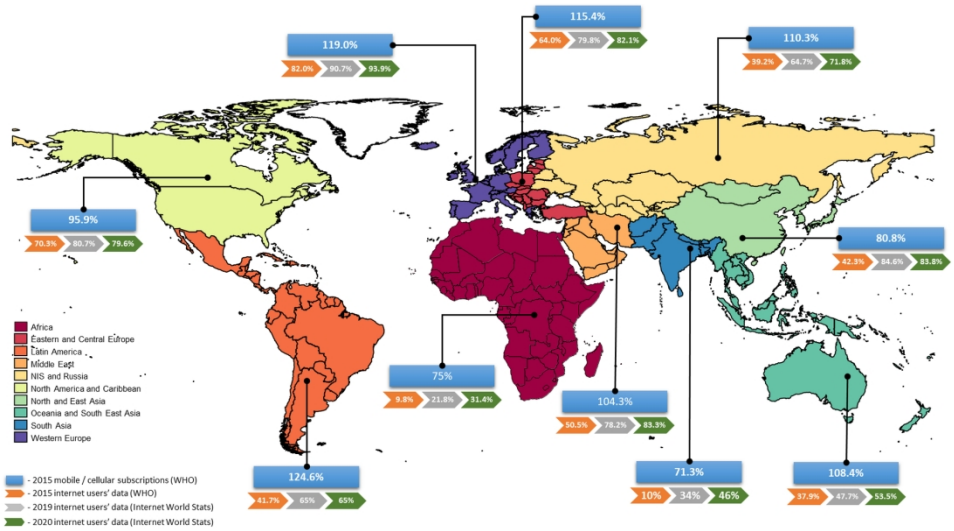

Figure 1

84x47mm (600 x 600 DPI)

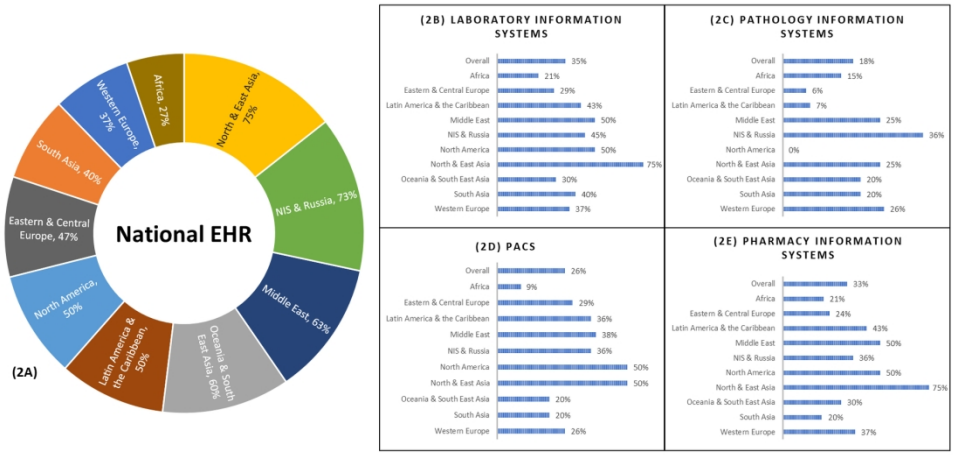

Figure 2

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Supplementary Materials:

Supplementary Table S1: List of participating countries by ISN regions

Africa		EC Europe	Latin America	Middle East	NIS & Russia	North America	North East Asia	OSEA	South Asia	Western Europe
Benin	Cabo Verde	Moldova	El Salvador	Syrian Arab Republic	Armenia	Jamaica	Korea, Dem. People's Rep.	Cambodia	Afghanistan	Austria
Burkina Faso	Cote d'Ivoire	Albania	Guatemala	Iran, Islamic Rep.	Georgia	Canada	China	Kiribati	Bangladesh	Belgium
Burundi	Ghana	Bosnia and Herzegovina	Honduras	Iraq	Kyrgyz Republic	Trinidad and Tobago	Mongolia	Lao PDR	Bhutan	Denmark
Central African Republic	Kenya	Bulgaria	Colombia	Jordan	Tajikistan	United States	Japan	Philippines	Pakistan	Finland
Comoros	Lesotho	Montenegro	Costa Rica	Lebanon	Ukraine			Timor-Leste	Maldives	Greece
Ethiopia	Mauritania	Romania	Cuba	Bahrain	Uzbekistan			Vietnam		Iceland
Gambia, The	Morocco	Serbia	Dominican Republic	Oman	Azerbaijan			Malaysia		Ireland
Guinea-Bissau	Senegal	Turkey	Mexico	Qatar	Belarus			Australia		Israel
Madagascar	Sudan	Croatia	Panama		Kazakhstan			New Zealand		Italy
Malawi	Zambia	Cyprus	Paraguay		Russian Federation			Singapore		Luxembourg
Mali	Algeria	Czech Republic	Peru		Turkmenistan					Malta
Niger	Botswana	Estonia	Argentina							Netherlands
Rwanda	Equatorial Guinea	Hungary	Chile							Norway
Somalia	South Africa	Latvia	Uruguay							Portugal
South Sudan	Tunisia	Lithuania								San Marino
Uganda	Seychelles	Poland								Spain
Zimbabwe		Slovenia								Sweden
										Switzerland
										United Kingdom

Supplementary Table S2: mHealth for accessing services [n (%)]

	Toll-free emergency						Appointment reminders						Treatment adherence					
	International	Regional	National	Intermediate	Local or peripheral level	No Response	International	Regional	National	Intermediate	Local or peripheral level	No Response	International	Regional	National	Intermediate	Local or peripheral level	No Response
Overall	3(2)	9(7)	75(60)	20(16)	18(14)	31(25)	0(0)	8(6)	39(31)	22(18)	38(30)	39(31)	1(1)	7(6)	15(12)	23(18)	35(28)	65(52)
ISN regions:																		
-Africa	0(0)	1(3)	16(48)	6(18)	4(12)	13(39)	0(0)	4(12)	12(36)	5(15)	8(24)	13(39)	1(3)	4(12)	6(18)	5(15)	9(27)	19(58)
-Eastern & Central Europe	0(0)	0(0)	9(53)	1(6)	1(6)	6(35)	0(0)	0(0)	6(35)	0(0)	6(35)	5(29)	0(0)	0(0)	2(12)	3(18)	4(24)	8(47)
-Latin America & the Caribbean	0(0)	1(7)	11(79)	4(29)	4(29)	0(0)	0(0)	1(7)	7(50)	2(14)	3(21)	3(21)	0(0)	0(0)	1(7)	4(29)	3(21)	7(50)
-Middle East	0(0)	0(0)	6(75)	0(0)	1(13)	1(13)	0(0)	0(0)	4(50)	3(38)	1(13)	1(13)	0(0)	0(0)	0(0)	1(13)	0(0)	7(88)
-NIS & Russia	0(0)	3(27)	5(45)	3(27)	3(27)	2(18)	0(0)	1(9)	1(9)	1(9)	4(36)	4(36)	0(0)	1(9)	1(9)	1(9)	4(36)	5(45)
-North America	0(0)	0(0)	4(100)	1(25)	1(25)	0(0)	0(0)	0(0)	0(0)	1(25)	2(50)	2(50)	0(0)	0(0)	0(0)	2(50)	2(50)	1(25)
-North and East Asia	0(0)	0(0)	2(50)	2(50)	1(25)	1(25)	0(0)	0(0)	0(0)	0(0)	3(75)	1(25)	0(0)	0(0)	0(0)	0(0)	1(25)	3(75)
-Oceania & South East Asia	1(10)	1(10)	8(80)	1(10)	2(20)	2(20)	0(0)	0(0)	2(20)	5(50)	3(30)	4(40)	0(0)	0(0)	1(10)	3(30)	4(40)	5(50)
-South Asia	0(0)	0(0)	1(20)	1(20)	0(0)	3(60)	0(0)	0(0)	1(20)	2(40)	2(40)	2(40)	0(0)	1(20)	2(40)	2(40)	1(20)	2(40)
-Western Europe	2(11)	3(16)	13(68)	1(5)	1(5)	3(16)	0(0)	2(11)	6(32)	3(16)	6(32)	4(21)	0(0)	1(5)	2(11)	2(11)	7(37)	8(42)
World Bank Groups:																		
-Low income	0(0)	1(5)	8(42)	3(16)	2(11)	9(47)	0(0)	2(11)	5(26)	4(21)	6(32)	7(37)	0(0)	2(11)	4(21)	4(21)	4(21)	11(58)
-Lower-middle income	1(3)	3(10)	18(60)	5(17)	6(20)	6(20)	0(0)	2(7)	12(40)	6(20)	8(27)	11(37)	1(3)	2(7)	5(17)	5(17)	9(30)	17(57)
-Upper-middle income	0(0)	0(0)	17(50)	8(24)	6(18)	10(29)	0(0)	1(3)	8(24)	5(15)	8(24)	14(41)	0(0)	2(6)	3(9)	3(9)	8(24)	20(59)
-High income	2(5)	5(12)	32(76)	4(10)	4(10)	6(14)	0(0)	3(7)	14(33)	7(17)	16(38)	7(17)	0(0)	1(2)	3(7)	11(26)	14(33)	17(40)

Figure S1: National eHealth policies / strategies across ISN regions

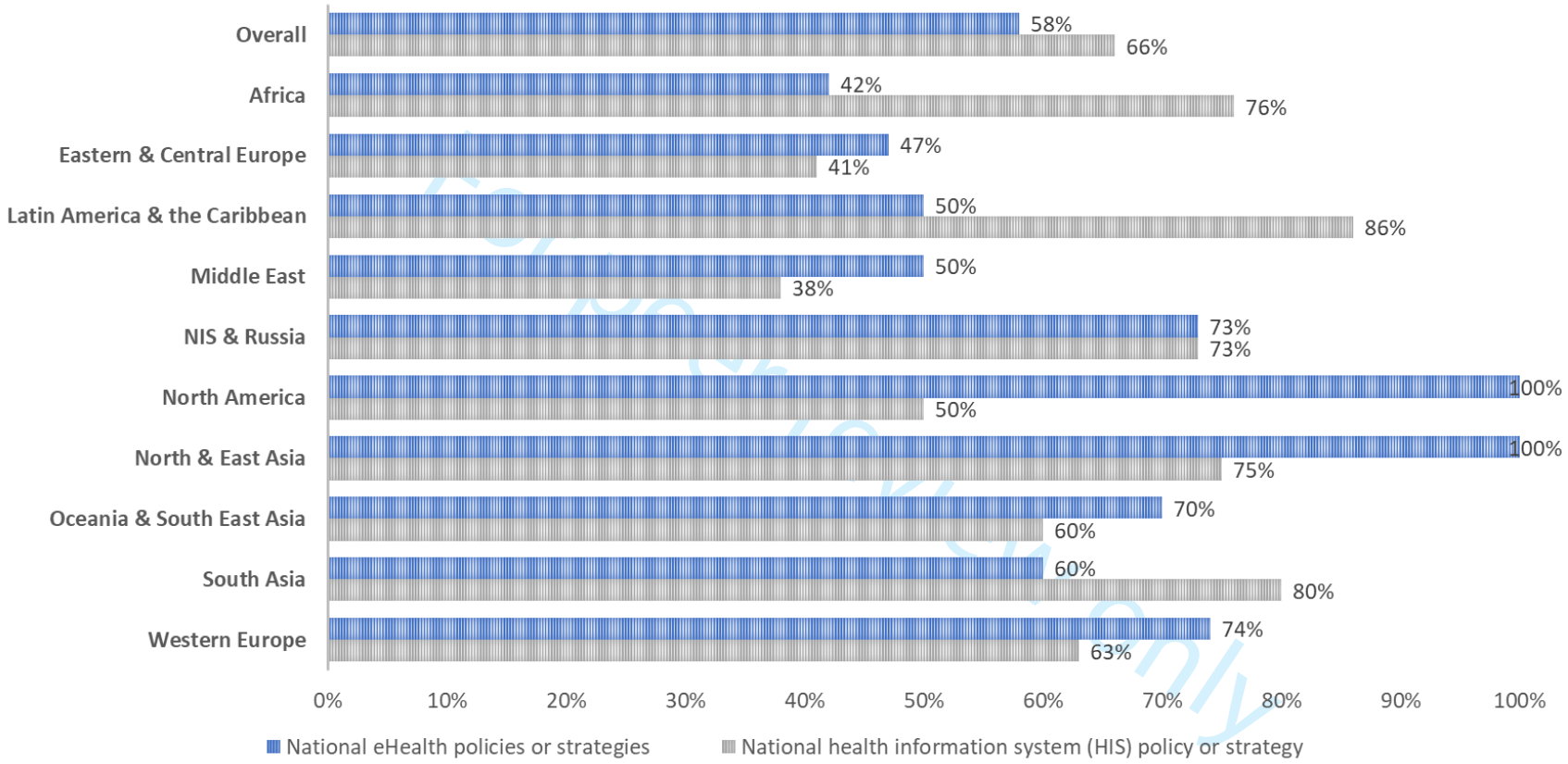


Figure S2: Funding sources for eHealth by income groups

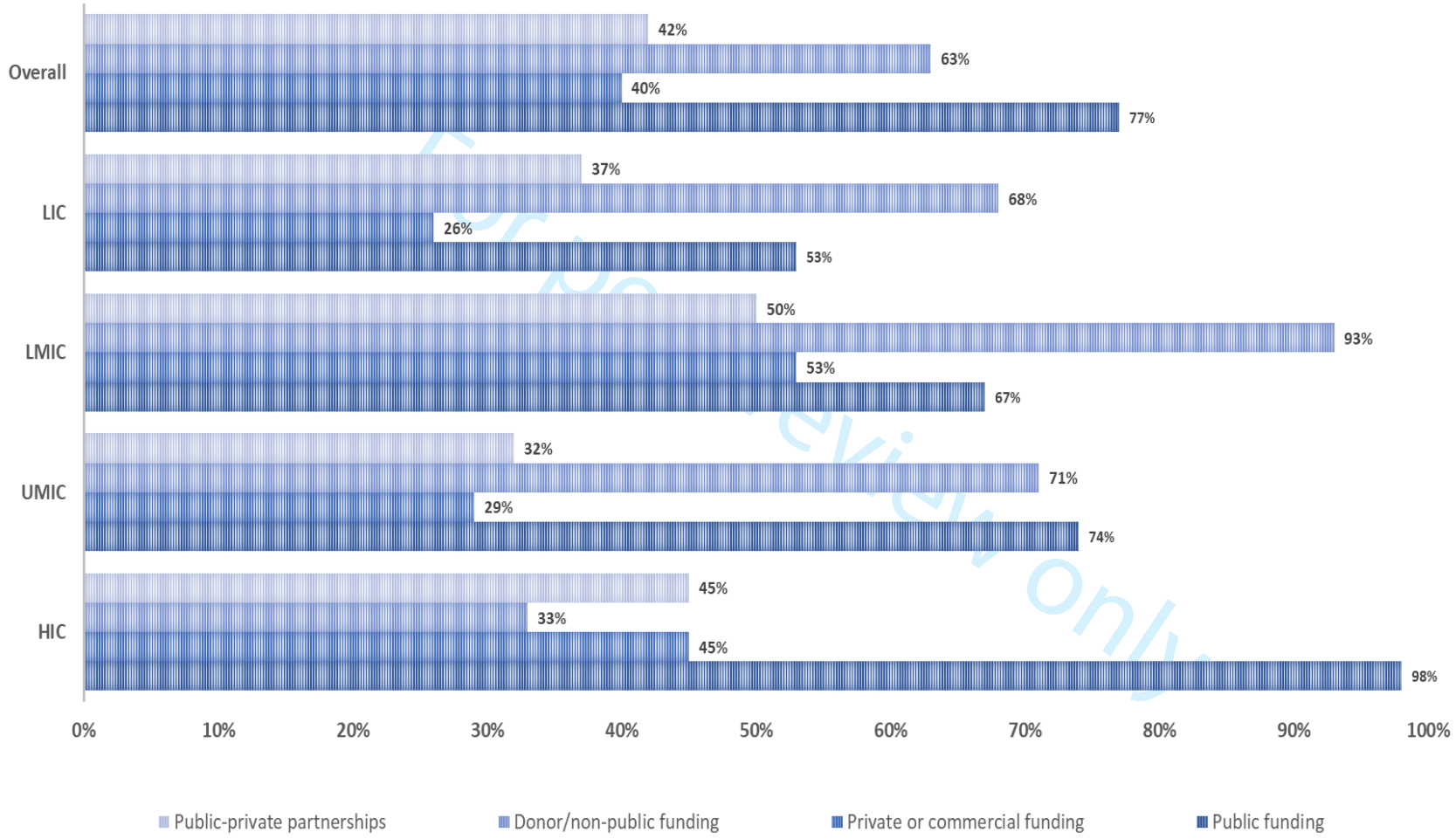


Figure S3: eHealth capacity building

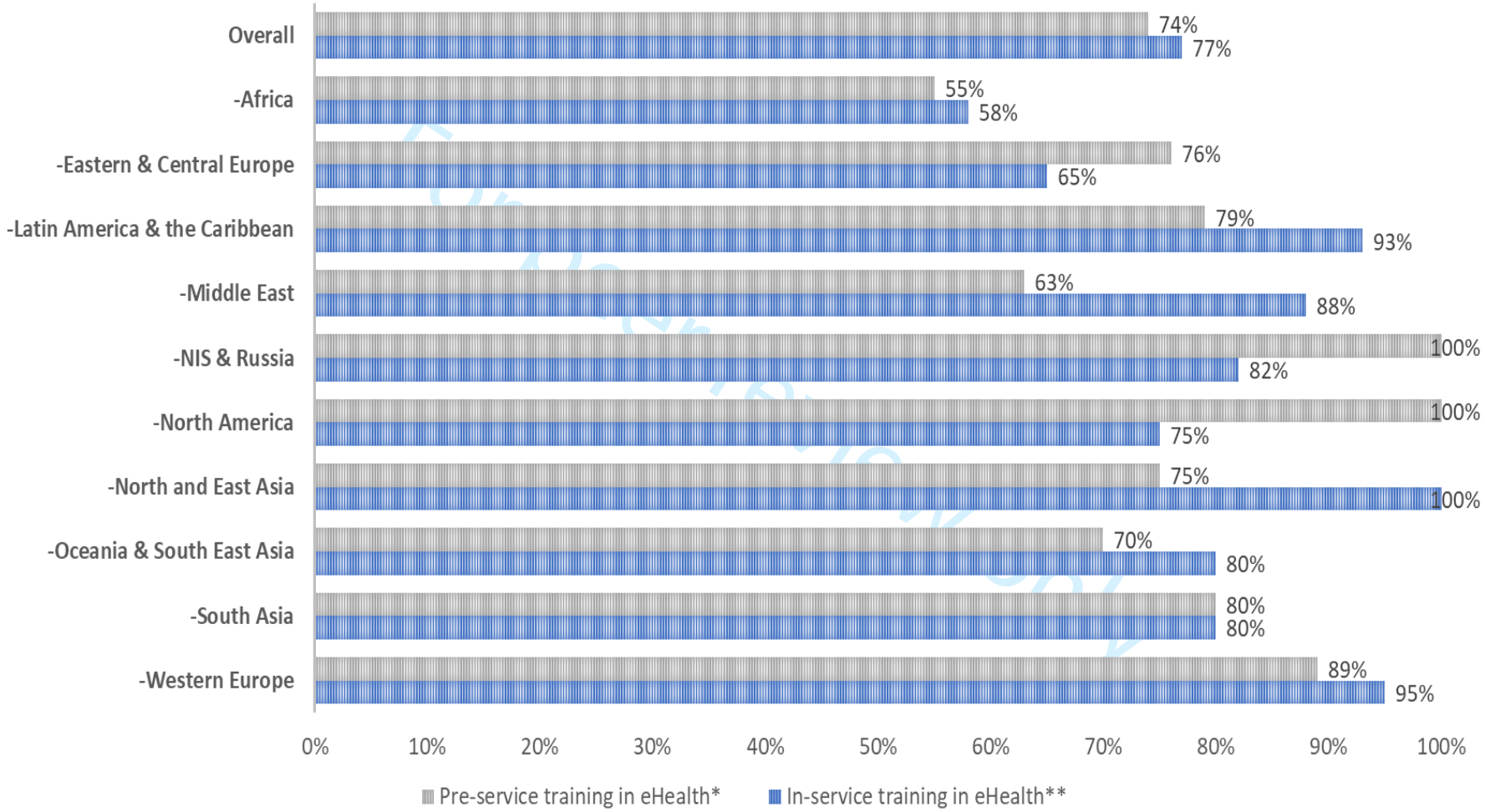


Figure S4: Use of e-learning in health sciences across ISN regions

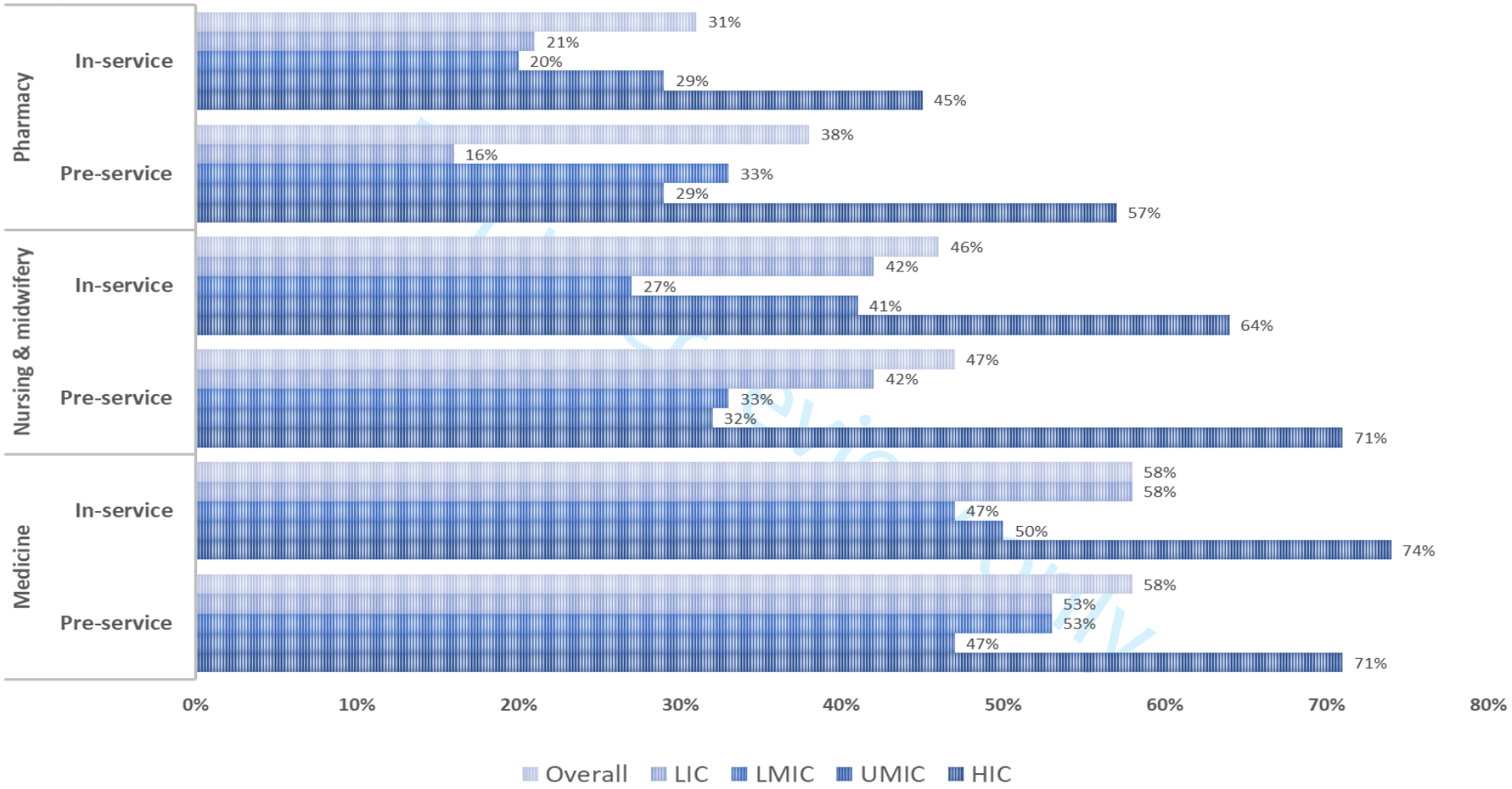


Figure S5: Health facilities with EHR in ISN regions

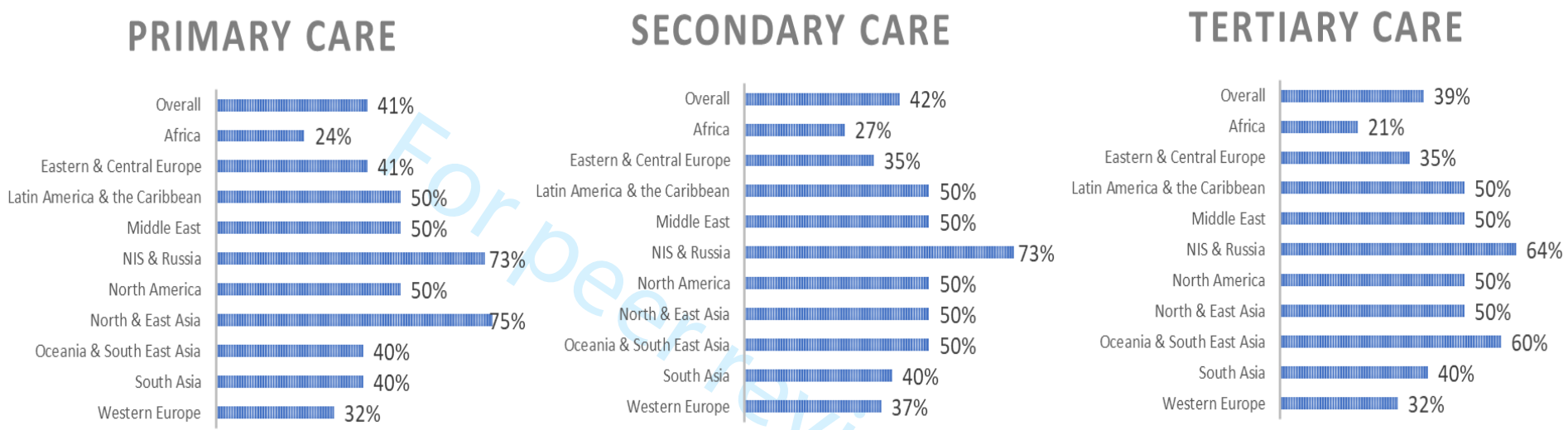


Figure S6: Availability of human resources for Health Information Systems (HIS)

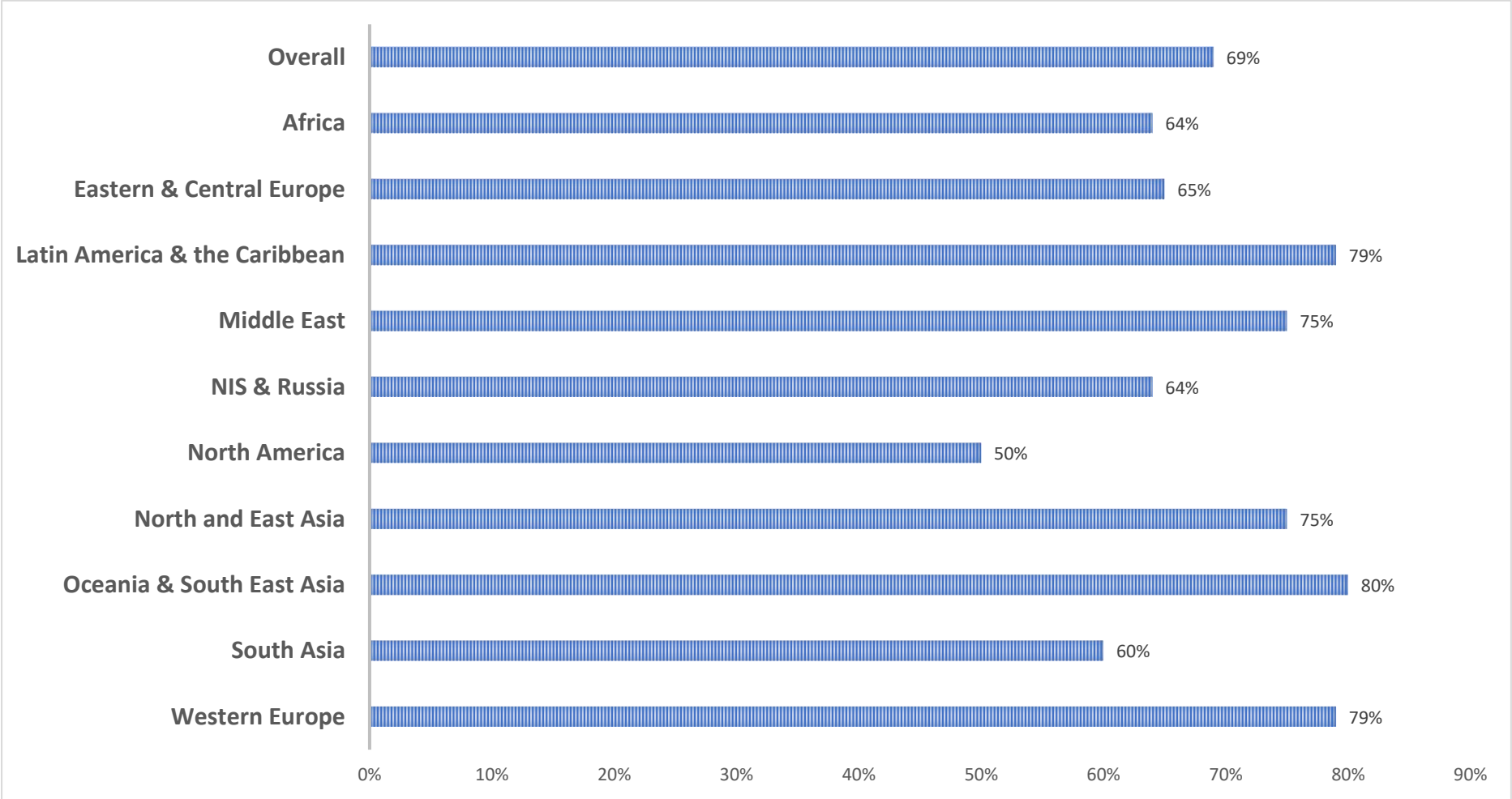


Figure S7: Legal framework for eHealth across income groups

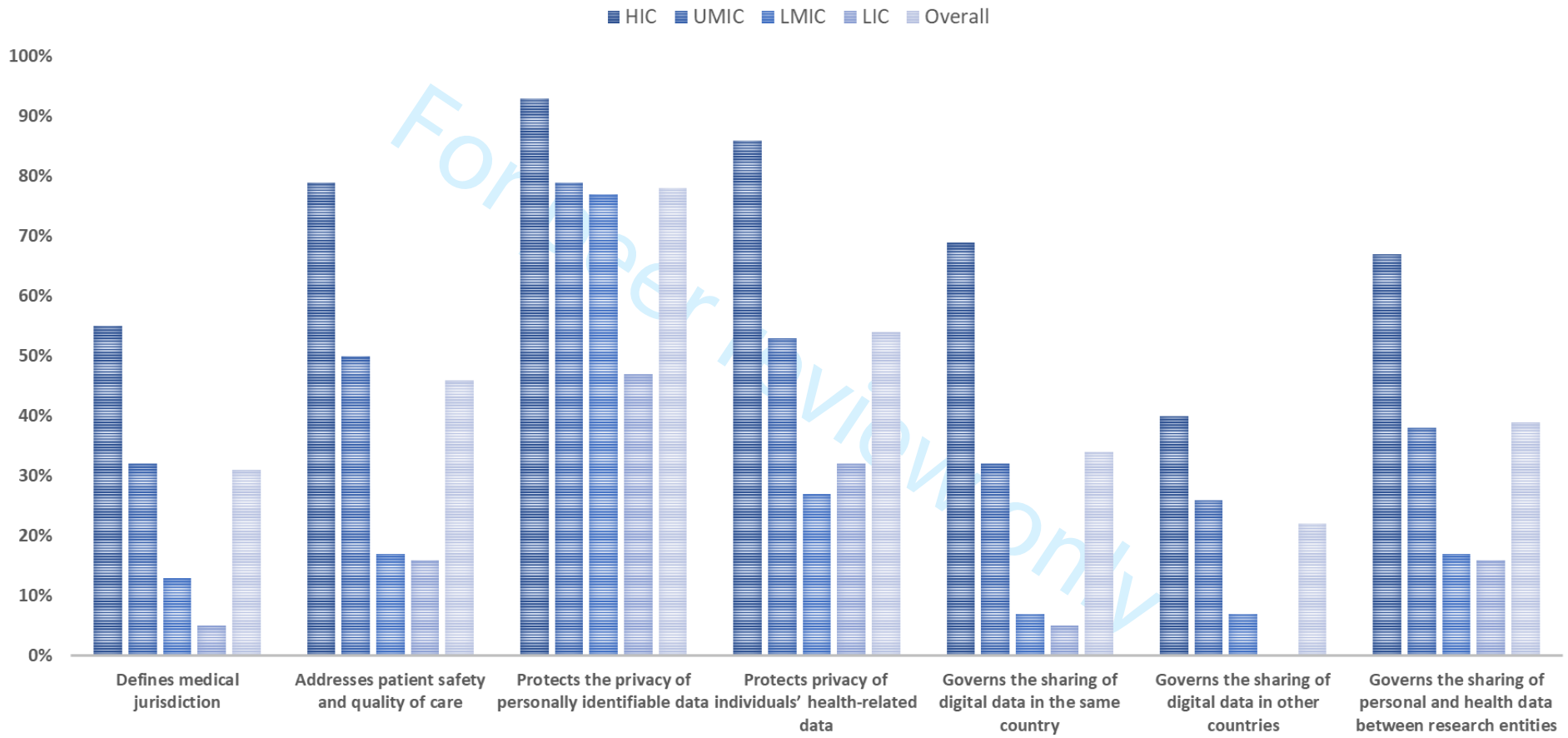


Figure S8: Health care organizations use of social media across ISN regions

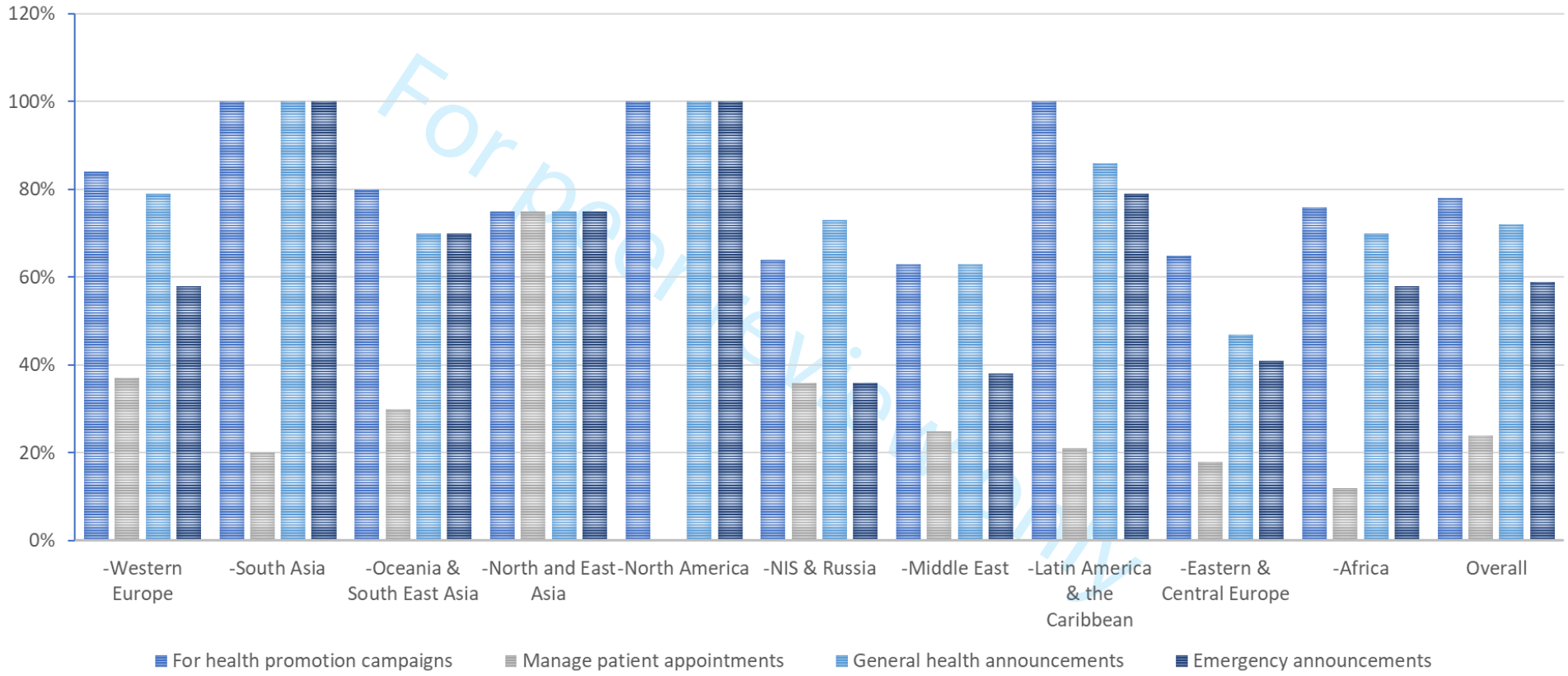
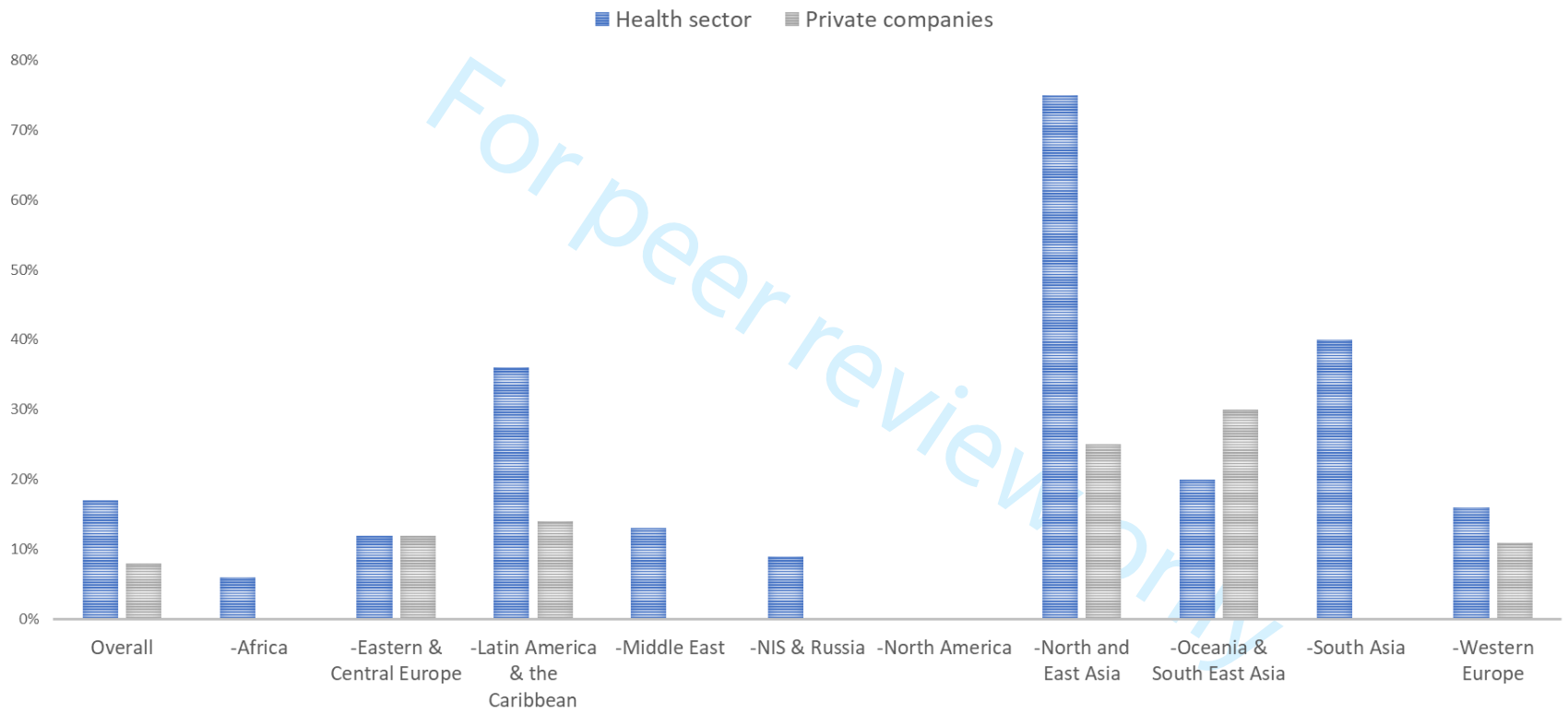


Figure S9: Policy / strategy governing the use of big data



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Global Status of Infrastructure and Opportunities for eHealth: Implications for Kidney Care Delivery in Low-income and Lower-Middle-Income Countries

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Title: Global Status of Infrastructure and Opportunities for eHealth: Implications for Kidney Care Delivery in Low-income and Lower-Middle-Income Countries.

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Abstract

Objective:

To describe the use of eHealth in support of health coverage for kidney care across eight eHealth themes: eHealth foundations, mobile health (mHealth), telehealth, eLearning, electronic health records, legal frameworks for eHealth, social media, and big data.

Design, setting and participants:

We used data from the World Health Organization (WHO) third global survey on eHealth, as well as data from the World Bank, and Internet World Stats on global eHealth services. Data were recategorized by International Society of Nephrology (ISN) regions and presented descriptively.

Outcome measures:

The availability of eHealth services (e.g., electronic health records (EHR), telehealth, etc) and governance frameworks (policies) for kidney care across ISN regions.

Results:

The survey conducted by the WHO received responses from 125 (64.4%) Member States representing 4.4 billion people globally. The number of mobile cellular subscriptions were < 100% of the population in Africa, South Asia, North America, and North-East Asia; percentage of internet users increased from 2015 to 2020 in all regions. Western Europe had the highest percentage of internet users in all the periods: 2015 (82.0%), 2019 (90.7%), and 2020 (93.9%); Africa had the least: 9.8%, 21.8% and 31.4%, respectively. The North-East Asia region had the highest availability of national EHR (75%) and eLearning access in medical schools (100%) with the lowest in Africa (27% and 39%, respectively). Governance policies of eHealth (e.g., privacy, liability, data sharing) were more widely available in high-income countries (55% to 93%) than in low-income countries (0% to 47%) while access to mHealth for treatment adherence was more available in low-income countries (21%) than in high-income countries (7%).

Conclusion:

The penetration of eHealth services across ISN regions is suboptimal, particularly in low-income countries. Increasing utilization of internet communication technologies provides an opportunity to improve access to kidney education and care globally, especially in low-income countries.

Strengths and Limitations of this study:

- This study identified gaps in eHealth services available for kidney care across countries and regions of the International Society of Nephrology (ISN).
- We highlighted the increasing availability of mobile / cellular subscriptions and the number of internet users observed in various countries from 2015 to 2020, especially those in low-income groups.
- The study also highlights the lack of policy and governance strategies relevant to eHealth (e.g., privacy, liability, data sharing / ownership), as well as poor utilization of eHealth for learning and health information systems.
- Although workforce shortages for learning, training and delivery of kidney care are more pronounced in low resource settings than in high-income countries, we emphasized that this can be substantially mitigated by leveraging the increasing availability of electronic platforms to improve kidney health.
- A limitation of this work may relate to the non-participation in the survey used for our study of a few countries with large populations in their regions.

Introduction:

Approximately 97% of people worldwide live within reach of a mobile cellular signal.[1] The widespread availability of this service can be a platform for increased utilization of registries, electronic health records and diseases surveillance systems to empower monitoring and reporting of disease incidence and prevalence,[2] patient outcomes,[3] and quality and safety of delivered care[3,4] as well as to allow comparison between and within health services.[5-7] eHealth is the cost-effective and secure use of information and communications technologies (ICT) in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research.[8] According to the World Health Organization (WHO), 87% of Member States have one or more national mHealth initiatives, 58% have an effective strategy for eHealth, 55% have legislation to protect electronic patient data.[8]

In the current era of the COVID-19 global pandemic, the potential for using eHealth to transform kidney disease management is increasingly recognized.[9,10] A cross-sectional survey conducted by the International Society of Nephrology (ISN) Global Kidney Health Atlas (GKHA) in 2017 reported low utilization of health information systems in the care of patients with kidney failure, especially in low-income countries (LICs) and lower-middle-income countries (LMICs).[11] However, the survey was limited by a focus on registries.[11] Furthermore, a systematic review of 43 studies that included 6,617 participants and evaluated the impact of an eHealth intervention in people with chronic kidney disease (CKD) did not find statistically significant improvements in the health domains assessed with eHealth in patients with CKD although eHealth was suggested to be useful for dietary sodium intake and fluid management.[12] However, other studies have shown that some forms of eHealth (e.g. telenephrology) are useful for improving access to kidney care in primary care settings,[13] for self-management for patients with CKD,[14] for nurse practitioner and nephrologist training

and education,[15,16] and for safe, economical and efficient care delivery in rural and remote areas.[17] The current manuscript describes the status of eHealth services and eHealth governance across ISN regions, using data from the World Health Organization (WHO) third global survey on eHealth which aimed to survey global eHealth, explore developments in eHealth since the previous survey, and its role in achieving universal health coverage.[18] We also appraise the implications of our findings for kidney care across ISN regions.

Methods

We leveraged published data from the WHO third global survey on eHealth.[18] The study, which was designed using a survey method is summarized as follows. The survey was developed and conducted by the WHO through the Global Observatory for eHealth (GOe) with input and consultation from experts in eHealth health. The survey assessed eight themes in eHealth including: (i) eHealth foundations, (ii) mobile health (mHealth), (iii) telehealth, (iv) eLearning, (v) electronic health records (EHR), (vi) legal frameworks for eHealth, (vii) social media and (viii) big data. Concise definitions of these themes are provided:

- **eHealth:**[19] the cost-effective and secure use of ICT in support of health and health related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research.
- **mHealth:**[18] the use of mobile devices, such as mobile phones, patient monitoring devices, Personal Digital Assistants, and wireless devices, for medical and public health practice including free telephone hotlines for emergencies provided by trained personnel and pre-recorded messages (toll-free emergency telephone services), reminder messages provided by health services to patients aimed at achieving medication adherence, reminder messages to patients to make or attend an appointment, etc..

- **Telehealth:**[18] the delivery of health care services through ICT for the exchange of information in real time (synchronously, e.g., by telephone or video link) or by store-and-forward methods (asynchronously, e.g., by email) for the diagnosis and treatment of diseases and injuries, research and evaluation, and for the continuing education of health professionals where patients and care providers are separated by distance.
- **eLearning:**[20] the use of ICT for education
- **Electronic Health Records (EHR):**[18] real-time, patient-centred records that provide immediate and secure information to authorized users and typically contain a patient's medical history, diagnoses and treatment, medications, allergies, immunizations, as well as radiology images and laboratory results.
- **Legal framework for eHealth:**[18] the legislative process addressing transfer and use of information between health care workers and patients that is relevant to issues of privacy and confidentiality of patient data, access rights and sharing rights for data, addressing data quality and integrity as a basis for clinical and patient decision-making and rules governing the adaptation of professional liability to accommodate care provided remotely or virtually.
- **Social Media:**[18] interactive platforms for individuals, communities and organizations to share and discuss content, debate issues and promote new ideas e.g. Facebook, Twitter or YouTube.
- **Big data:**[18] refers to extremely large data sets that encompass a range of data including clinical data from electronic health records; the phenotype; genomic information; and data on other determinants of health such as environment and lifestyle.

The survey was developed in English and translated into seven languages (Arabic, Chinese, English, French, Russian, Spanish and Portuguese) to improve country responses

and accuracy of responses. A web-based tool, (LimeSurvey - https://www.limesurvey.org/en/), was used for online form creation, data collection and management. WHO regional offices staff assisted in coordinating the survey process and liaising with the GOe Secretariat in Geneva. National level survey coordinators, together with relevant ministries and academic and research institutions identified between 5 and 10 national expert informant groups in eHealth to participate in the survey. The group consisted of eHealth specialists, professionals in telehealth, EHRs, mHealth and statisticians responsible for national health data. Expert informants met for one day to reach consensus on a single national-level response. Hence, each participating country submitted a single national survey with input from its group of expert informants. The survey was conducted between 1 April and 30 June 2015. Data on ICT indices (a composite index of fixed-telephone subscriptions, mobile-cellular telephone subscriptions, international Internet bandwidth per Internet user, households with a computer, and households with Internet access; scored as low as 0 to as high as 100 and presented in unit scores) were obtained from the World Bank[21] while more recent (2019 and 2020) data on internet usage were obtained from Internet World Stats (https://www.internetworldstats.com/).

Data handling and processing

After receiving the completed questionnaires, all non-English responses were translated into English and survey responses were checked for consistency. Data were then analyzed by thematic sections using computed percentages for each "yes" response to obtain the overall results for all responding countries and regions. We regrouped country responses using the ten ISN regional classification: Africa, East and Central Europe, Latin America, Middle East, Newly Independent States (NIS) and Russia, North America and Caribbean, North and East Asia, Oceania and South East Asia (OSEA), South Asia and Western Europe (https://www.theisn.org/about-isn/governance/regional-boards/). Country responses were also

grouped according to World Bank income groups. Data on mobile-cellular subscriptions and internet users in each region were provided as the median percentage of the total population of participating regions. No statistical comparisons were used for describing the data which were presented in percentages.

Patient and public involvement:

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Results

(i) Participating country indices

A response to the survey was received from 125 WHO Member States out of 194 Member States that were surveyed, representing a response rate of 64.4% and a total population of 4.39 billion people. The list of participating countries based on ISN reginal groups is presented in Supplementary Table S1 and a summary of the demographic, economic and health metrics for each region is shown in Table 1. Overall, the median ICT development index for participating countries was 4.8 (95% CI: 2.9-6.9). Four regions: Africa (2.3), South Asia (2.3), OSEA (4.0) and Latin America (4.4) had lower indices compared to the median value while Western Europe had the highest (7.9). Subscriptions to mobile-cellular networks was highest in the Latin America region (124.6% [95% CI: 89.9 – 142.7]) and lowest in South Asia (71.3% [95% CI: 63.7 – 120.6]) while percentage of the population that used the internet was highest in Western Europe (82.0% [95% CI: 70.0 – 93.0]) and lowest in Africa (9.8% [95% CI: 3.0 – 18.1]) (Figure 1). However, internet users increased across all regions in 2019 and 2020, including Africa (21.8% and 31.4%, respectively) and South Asia (34% and 46%, respectively) (Figure 1).

(ii) National eHealth policies, funding, and capacity building

A national policy for eHealth was available in all participating countries in North America (100%) and North-East Asia (100%) and was lowest in participating countries from Africa (42%) and East and Central European countries (47%) (Figure S1). Availability of policies governing health information systems in countries across regions also varied across regions. Overall, participating countries reported multiple sources of funding for eHealth including public (77%), donor (non-public) (63%), private (commercial) (40%) and public-private partnerships (42%) and LICs and LMICs relied more on donor funding for eHealth services (Figure S2). Overall, pre-service, and in-service training in eHealth were available in 74% and 77%, respectively. Pre-service training was lowest in Africa (55%) and highest in NIS and Russia (100%) and North America (100%). In-service training was lowest in Africa (58%) and highest in North and East Asia (100%) (Figure S3).

(iii) mHealth

Data on access to mHealth across 3 of the 6 domains reported (toll-free emergency, appointment reminders and treatment adherence) are provided in Supplementary Table S2. International toll-free emergency access to mHealth was available in only 2 regions: OSEA (10%) and Western Europe (11%) and was unavailable in all regions for appointment reminders. National toll-free emergency access to mHealth services was variably available in all regions. Access to National mHealth services for treatment adherence was mostly available in low-income countries (21%) and was lowest in high-income countries (HICs) (7%).

(iv) Telehealth

Teledermatology, telepathology, teleradiology and telepsychiatry were reported but telenephrology programs were not reported. Nonetheless, services to remote patient monitoring were mostly available in HICs (40%) and at the local / peripheral health care system level with the program fully established only in 26% of countries (Table 2).

(v) eLearning

The availability of eLearning for health sciences students (pre-service) and health professionals (in-service) in Medicine (Medical School), nursing and midwifery and pharmacy are reported in Figure S4. Use of eLearning in medical school was highest in North-East Asia (100%) and lowest in South Asia (40%) and Africa (39%). North-East Asia also had the highest use of eLearning services for pre-service training of nurses and midwives (75%) and pharmacists (100%). Use of eLearning for pharmacists training was unavailable in South Asia (Figure S4).

(vi) Electronic health records (EHR) systems

National EHR systems were mostly available in in North-East Asia (75%) while countries in Africa had the least availability of EHR systems (27%) (Figure 2A). Overall, secondary healthcare facilities were more likely to have EHR systems (42%) than primary healthcare (41%) or tertiary healthcare facilities (39%) (Figure S5). Secondary and tertiary facilities in the NIS and Russia region had the highest availability of EHR systems (73% and 64%, respectively) while all tiers of healthcare facilities in Africa had the lowest (Figure S5). Availability of laboratory information systems, pathology information systems, picture archiving and communication system (PACS) and pharmacy information systems by income groups are shown in Figures 2B-2E with most regions reporting low availability of these systems for healthcare. Human resource availability for health information systems was similar across income groups but was highest in the Oceania and the South-East Asia region (80%) (Figure S6).

(vii) Legal frameworks for eHealth

Aspects of the legal framework governing use of eHealth were not readily available across countries and regions (Figure S7). For instance, countries from the South Asia region, did not have frameworks governing liability or reimbursement for eHealth, patient safety and

quality of care based on data quality, protection of the privacy of individuals, sharing of digital data between health professionals and sharing of personal health data between research entities (Figure S7).

(viii) Social media

National policy on use of social media by government organizations was lacking and ranged from as low as 9% in the NIS and Russia region to 50% in the North-East Asia region. However, specific policy on the use of social media in the health domain was unavailable in six regions (Eastern and Central Europe, Latin America, Middle East, NIS & Russia, North America and South Asia). When utilized, social media were mostly used for making emergency announcements, general health announcements and for health promotion campaigns (Figure S8).

(ix) Big data

Information on policy or strategies that govern use of big data in the health sector and private companies was sparsely reported. North-East Asia had the highest proportion of policies in the health sector (75%) whilst Africa had the least (6%). No data was obtained for North America. (Figure S9).

Discussion

The United Nations Sustainable Development Goals emphasizes the great potential of the spread of information and communications technology and global interconnectedness to accelerate human progress, and to bridge the digital divide to develop knowledge in societies.[22] The ISN-GKHA has identified large and varied gaps in resources and workforce required for adequate provision of kidney care across several countries, particularly in LICs and LMICs in all the ISN regions. eHealth services may be potential vehicle to harness local resources for improvements in kidney care. This study, which mainly analyzed WHO eHealth survey data using the ISN regional groups, found low ICT development indices mostly in

LIC and LMICs, low availability of national EHR and proportion of national eHealth policies in LICs and LMICs, increased utilization of mHealth services in low-income settings, lack of use of eLearning across regions and absence of legal frameworks governing use of eHealth in several ISN regions. These findings underscore the need for concerted action if eHealth is to achieve its potential for reducing inequities in kidney care across regions and countries.

A major challenge in accessing kidney care in many countries is the lack of skilled workforce, specifically the absence of an adequate number of nephrologists.[23] The nephrologist density in HICs in North America and Western Europe is more than 90 times that in low-income countries in Africa, South Asia and Oceania region (28.52 per million population [pmp] vs. 0.31 pmp),[24] suggesting a clear disadvantage in care access for populations with low nephrologist densities.[25] In a global survey Lunney et al identified geography and low nephrology workforce to be associated with lack of access to kidney care, especially in low-income countries.[26] Low nephrology workforce, particularly in rural or remote areas often means long travel distance to access care[27] with potentially negative consequences, including increased cost of care, low quality of life,[28] lack of access to kidney replacement therapies (KRT; i.e. dialysis and transplantation)[28-30] and increased likelihood of death.[31] In a large South African Province with only 2 public service nephrologists, a study that assessed the predictors of mortality in rural dwelling patients receiving KRT at a district hospital, found mortality to be higher in PD patients ($P<0.001$) who travelled farther to reach the hospital than those treated with HD.[29] These challenges are not limited to low resource countries. One study from Australia estimated that use of telehealth services for evaluating post-transplant patients resulted in a net saving of 203,202 kilometres in patient travel distance; 2771 hours in car travel time; about AUD $31,048 in petrol savings and 51 tonnes CO_2 equivalents of greenhouse gas emissions.[27] Due to the widespread availability of mobile cellular signals,[1] cellular and internet technologies have potential to improve access to

nephrology care in remote and/or underserved settings. Access to care can also be improved in children with kidney diseases given the significant shortage of paediatric nephrologists[32] and mitigate high mortality identified in children with kidney failure in regions such as Africa.[33] The global COVID-19 pandemic demonstrates that use of eHealth technologies will likely increase over the coming years,[34,35] thereby highlighting the need to strengthen governance on how eHealth systems are utilized across ISN regions. Care of patients with CKD has been grossly affected during the pandemic, and it falls upon the stakeholder community to develop sustainable solutions.

The prevalence of CKD risk factors such as hypertension and diabetes mellitus continue to increase globally. The rise is projected to be significant, especially in LICs and LMICs of South and South East Asia and Africa.[36,37] For instance, globally, 79% of people with diabetes live in LICs or LMICs (mostly Oceania, South and South East Asia region) and projections of diabetes prevalence by 2045 suggest an increase of 143% in Africa, 96% in the Middle East and 74% in South East Asia compared with 15% and 33% increase in Europe and North America, respectively.[36] Innovative models of care delivery are therefore needed to manage the growing disease burden. Given the wide coverage of mobile phone networks, mHealth holds promise as an important delivery tool for health care delivery in resource constrained regions (Figure 1). mHealth interventions are in use for diagnosis and management of various infectious diseases including malaria,[38] tuberculosis,[39] and HIV[40] and for improving maternal and foetal health[41] in several developing countries. Although mHealth interventions are increasingly used for non-communicable diseases,[42-44] some studies highlight only a modest impact in NCD control likely due to limited number of studies and impact on process of care alone.[45,46] Our analysis showed that use of mHealth (appointment reminders and treatment adherence) and telehealth services (remote patient monitoring) were much higher in LICs and LMICs than in HICs (Supplementary Table S2 and Table 2). In a

study conducted in a rural Indonesian population multifaceted mobile technology–supported primary health care intervention was associated with greater use of preventive CVD medication and lower BP levels among high-risk individuals.[47] These findings suggest that despite the relatively low current use, mHealth may be potentially useful for supporting case-finding for CKD,[44] CKD-specific education to improve awareness, integrated care delivery and efficient referral pathways, and perhaps allow quality control through real-time monitoring.[48]

To guide implementation, ethical issues including type and quality of digital technology, doctor-patient relationship, data confidentiality and security, informed consent and patients and families satisfaction with telemedicine services should be considered in framing legal governance for eHealth.[49] Increasing the use of such technologies will require demonstration of public benefits (e.g. cost saving),[50] while ensuring that there is no discrimination or digital inequality (e.g. not tailored to only those with a smartphone or for the disabled)[51] and to protect patient and data privacy.[52] As our study shows, the legal frameworks that govern sharing of personal health data or digital data and protect the privacy of individual health-related data were either low or absent in many regions. There is need to address such legislation in all regions (Figure S7).

Our study also identified EHR use to be low in LICs and LMICs with poor utilization of eLearning for pre-and in-service training in the health sectors (Figure S5). Barriers that impede adoption and/or implementation of EHR systems such as cost (including setting up, maintenance and ongoing costs), technical concerns, technical support, resistance to changing work habits, loss of income and loss of productivity will need to be identified in each setting and addressed. As Kruse et al[53] have suggested, policy makers will need to consider incentives that reduce the implementation cost of EHR, possibly aimed more directly at organizations that are known to have lower adoption rates, such as small hospitals in rural

areas. However, this may be possible in HICs where such technologies are readily available, whereas in LICs and LMICs, such incentives should be targeted towards secondary and tertiary care centres that serve a wider population. Measures that ensure successful adoption and implementation of EHR technology including systems usability (acceptable and ease of use), interoperability (functional across platforms, e.g., IOS and Android), and adaptability (fitting the technology into local context, e.g., language) need to be considered in terms of local context, individual end-users and advancing technology.[54]

The potential and value of eLearning in addressing workforce shortages[20,55] and the educational needs of health professionals, especially in developing countries is well recognized.[56] The ISN fellowship program recently included hybrid (online plus hands-on) training as part of the strategy for improving training of nephrologists from low-resource settings.[23] This can improve training in glomerular diseases (histopathology), assessment of urine microscopic findings as well as various aspects of interventional nephrology including dialysis catheter insertion and care. A number of groups have used virtual platforms to upskill healthcare workers in the care of patients with COVID-19 in India and Africa.[57] Access to the basic IT infrastructure (e.g. computers and internet) remains a major hurdle to the implementation of technology-enhanced teaching in developing countries.[56] Any solution should be sensitive to local resources and be designed to operate at low cost (data, device). One study that assessed the awareness, attitudes, preferences, and challenges to eLearning among medical and nursing students at Makerere University, Uganda identified low monthly income, quality of internet connectivity and lack of computer ownership among factors that significantly affected attitudes towards eLearning.[58] Perceived advantages of online learning by medical students in the UK included time and money saved from lack of travel and flexibility and ability to learn at one's own pace whereas family distractions, internet connection and the timing of tutorials were identified as barriers.[59] The extent of integration

of eLearning in health sciences (Medicine, Nursing and midwifery and Pharmacy) for both pre- and in-service training was low in most regions in our study (Figure S4). The impact of an improved integration of eLearning in health sciences will be widespread across all medical disciplines.

There were a few limitations to this study previously described in the WHO report.[18] These include that the report is old (2015), given that there are no other reports superseding this with a global reach. However, our study has made up for this by the inclusion of newer data from elsewhere showing availability and use of telecommunications services as a proxy for use of eHealth that rely on such services. Also, WHO Member States were limited to one response per country i.e., expert informants were required to propose a consensus response for each question which was difficult in cases where the situation varied widely within the country. Furthermore, although every effort was made to select the best national experts to complete the instrument; the knowledge capacity of each focus group to accurately answer the questions was not determined. Another limitation of this study is the focus on large hospitals and private health institutions as all eHealth capacities and strategies (e.g., primary care level or general practitioner clinics) may not have been adequately captured, thus underestimating its use across countries. However, this data provides a broad scan of the availability of these services across participating countries and regions, therefore useful for monitoring progress and for improving services. Finally, some countries with large populations (e.g., France, Germany, Brazil, Egypt, Nigeria, and India) did not participate in the 2015 survey. This is likely to have affected some of the results of this survey e.g., proportion with access to the internet. Despite the limitations, this study is the first to present a comprehensive overview of the status and penetration of eHealth in ISN regions using data from the WHO global survey on eHealth. Our study has also been able to address identified

gaps in availability of eHealth services and the implications of these for kidney care across ISN regions, particularly for LICs and LMICs.

Conclusion:

There is wide variation in the availability and accessibility of eHealth services across ISN regions with much reduced availability and access in LICs and LMICs. This is likely to have a significant negative impact for adequate kidney care provision in these regions, especially at a time when there are global restrictions in face-to-face contacts. Even though much infrastructure is required to set up such services, simple steps can be initiated towards broader use of eHealth services to aid care including legislations and provision of national guidelines / requirements on use of these technologies. Infrastructure development to improve access to the internet will need to be improved across regions especially in low-income countries. With rapidly evolving ICT technologies and as digitalization of medical education and care continues to gather pace in the future of healthcare, further research on the impact of eHealth in care of patients with kidney diseases is critical. The development of and access to appropriate technologies which facilitate equitable and high-quality care are needed to ensure no one is left behind.

Contributors: AKB conceptualized the research; SM, DZ and SS collated and checked the data for accuracy and completeness; FY analyzed the data; IGO designed the figures and Tables and drafted the first version of the manuscript. IGO, SM, FY, DZ, AG, MTi, SS, MO, JL, MTo, FC, CG, APK, CM, SD, AL, DWJ, VJ, and AKB provided inputs for the interpretation of results and documentation of implications of the study findings in the discussion. IGO, SM, FY, DZ, AG, MTi, SS, MO, JL, MTo, FC, CG, APK, CM, SD, AL, DWJ, VJ, and AKB contributed to the preparation of the final version, read, and agreed with the final version of the manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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FIGURE LEGENDS

Figure 1: Proportion of mobile-cellular users and internet access across ISN regions

Figure 2(A – E): (A) Availability of national EHR system, (B - E) Availability of other electronic health record systems (laboratory information systems, pathology information systems, PACS systems, and pharmacy information systems)
Abbreviations: EHR – electronic health records, PACS - picture archiving and communication system)

Supplementary Materials:

Table S1: List of participating countries by ISN regions

Table S2: mHealth for accessing services

Figure S1: National eHealth policies / strategies across ISN regions

Figure S2: Funding sources for eHealth by income groups

Figure S3: eHealth capacity building

Figure S4: Use of e-learning in health sciences across ISN regions

Figure S5: Health facilities with EHR in ISN regions

Figure S6: Availability of human resources for Health Information Systems

Figure S7: Legal framework for eHealth across income groups

Figure S8: Health care organizations use of social media across ISN regions

Figure S9: Policy / strategy governing the use of big data

Table 1: Features of participating countries ranked according to ISN regions and World Bank groups

	Total population of participating countries (millions)*	GNI per capita (PPP Int $) *	Physician density (per 10,000 population)	Nurse & midwife density (per 10,000 population)	Hospital bed density (per 10,000 population)	Life expectancy at birth (years)	Total health expenditure (% GDP)	ICT Development Index**
Overall (n=125)	4,389.9	18220 (18722)	1.63 (0.31-3.24)	2.53 (0.74-6.11)	28 (13-49)	74 (66-78)	6.7 (5.4-8.9)	4.8 (2.9-6.9)
ISN regions:								
-Africa (n=33)	600.7	4873 (6190)	0.11 (0.06-0.29)	0.68 (0.42-0.91)	13 (5-20)	60 (57-64)	5.7 (4.4-7.1)	2.3 (1.6-3.7)
-Eastern & Central Europe (n=17)	197.2	18943 (6815)	2.39 (2.02-3.38)	5.50 (4.16-6.27)	54 (39-66)	75 (74-77)	7.2 (5.9-8.0)	6.4 (5.8-6.9)
-Latin America & the Caribbean (n=14)	330.6	12952 (5452)	1.48 (1.11-2.10)	1.04 (0.62-1.51)	14 (10-21)	77 (74-78)	7.3 (6.4-8.8)	4.4 (3.6-6.0)
-Middle East (n=8)	152.3	38863 (40229)	1.95 (0.91-2.88)	2.72 (1.87-5.38)	18 (14-18)	76 (74-78)	5.1 (3.0-7.0)	5.9 (4.7-6.8)
-NIS & Russia (n=11)	278.4	11351 (7072)	3.47 (2.53-3.93)	7.11 (5.02-9.04)	52 (40-87)	69 (69-72)	6.1 (4.5-6.8)	5.3 (5.2-6.4)
-North America (n=4)	359.4	32815 (19823)	1.63 (0.79-2.26)	6.42 (2.33-9.55)	28 (23-31)	77 (73-81)	8.4 (5.7-14.0)	6.6 (4.9-7.9)
-North and East Asia (n=4)	1,548.2	19430 (15835)	2.57 (1.90-3.06)	3.87 (2.64-7.80)	95 (50-135)	73 (69-80)	6.0 (5.6-10.3)	4.8 (4.5-8.3)
-Oceania & South East Asia (n=10)	276.2	20210 (24142)	1.17 (0.18-1.95)	3.50 (1.11-6.00)	23 (14-31)	74 (67-82)	5.3 (4.0-9.4)	4.0 (2.8-7.9)
-South Asia (n=5)	370.4	5366 (3238)	0.36 (0.27-0.83)	0.57 (0.50-0.98)	6 (4-18)	68 (66-71)	3.7 (3.6-8.1)	2.3 (2.2-3.1)
-Western Europe (n=19)	276.6	40262 (11395)	3.49 (3.15-4.10)	8.80 (4.96-15.20)	46 (33-56)	81 (81-82)	9.4 (8.9-10.6)	7.9 (7.5-8.5)
World Bank Groups:								
-Low income (n=19)	353.6	1390 (429)	0.07 (0.04-0.12)	0.53 (0.26-0.77)	10 (4-17)	59 (56-62)	6.2 (4.8-8.1)	1.6 (1.3-1.9)
-Lower-middle income (n=30)	899.9	4816 (2102)	0.38 (0.17-1.60)	0.90 (0.62-3.71)	14 (7-31)	69 (64-72)	5.8 (4.2-6.9)	3.1 (2.4-4.0)
-Upper-middle income (n=34)	2,200.5	14547 (4236)	1.49 (1.15-2.56)	3.28 (1.41-5.41)	27 (17-54)	74 (72-76)	6.3 (5.4-7.2)	4.7 (4.4-5.9)
-High income (n=42)	936.0	38213 (19296)	3.27 (2.43-3.78)	6.27 (4.46-10.86)	38 (32-56)	81 (77-82)	8.9 (6.7-9.7)	7.5 (6.8-8.1)

* - data expressed as mean (SD); all other data represent median and interquartile ranges (IQR)
§ - (per 10,000 population)
** - Data from the World Bank (2015)
GNI – gross national income; PPP – purchasing power parity; GDP – gross domestic product; ICT – Information and communications technology

Table 2: Remote patient monitoring [n (%)]

	Health system level*						Programme type**			
	International	Regional	National	Intermediate	Local or peripheral level	No response	Informal	Pilot	Established	No response
Overall (n=125)	4(3)	4(3)	19(15)	21(17)	28(22)	65(52)	12(10)	38(30)	15(12)	67(54)
ISN regions:										
-Africa (n=33)	2(6)	0(0)	3(9)	2(6)	4(12)	25(76)	2(6)	5(15)	1(3)	25(76)
-Eastern & Central Europe (n=17)	1(6)	1(6)	3(18)	2(12)	5(29)	6(35)	2(12)	9(53)	0(0)	6(35)
-Latin America & the Caribbean (n=14)	0(0)	0(0)	1(7)	1(7)	4(29)	9(64)	1(7)	4(29)	1(7)	9(64)
-Middle East (n=8)	0(0)	0(0)	0(0)	2(25)	1(13)	5(63)	1(13)	1(13)	1(13)	5(63)
-NIS & Russia (n=11)	0(0)	1(9)	2(18)	3(27)	2(18)	5(45)	3(27)	3(27)	1(9)	5(45)
-North America (n=4)	0(0)	0(0)	0(0)	2(50)	1(25)	2(50)	0(0)	1(25)	1(25)	3(75)
-North and East Asia (n=4)	0(0)	0(0)	2(50)	0(0)	1(25)	1(25)	0(0)	1(25)	1(25)	2(50)
-Oceania & South East Asia (n=10)	0(0)	0(0)	0(0)	0(0)	3(30)	7(70)	0(0)	3(30)	0(0)	7(70)
-South Asia (n=5)	1(20)	0(0)	1(20)	1(20)	0(0)	2(40)	0(0)	2(40)	1(20)	2(40)
-Western Europe (n=19)	0(0)	2(11)	7(37)	8(42)	7(37)	3(16)	3(16)	9(47)	8(42)	3(16)
World Bank Groups:										
-Low income (n=19)	0(0)	0(0)	3(16)	1(5)	2(11)	13(68)	1(5)	3(16)	1(5)	14(74)
-Lower-middle income (n=30)	2(7)	1(3)	3(10)	3(10)	3(10)	21(70)	3(10)	6(20)	1(3)	21(70)
-Upper-middle income (n=34)	0(0)	0(0)	3(9)	4(12)	6(18)	22(65)	2(6)	9(26)	2(6)	22(65)
-High income (n=42)	2(5)	3(7)	10(24)	13(31)	17(40)	9(21)	6(14)	20(48)	11(26)	10(24)

*

International level – health entities in other countries in the world
Regional level – health entities in countries in the same geographic region
National level – referral hospitals, laboratories, and health institutes
Intermediate level, covering district or provincial facilities – public, private for-profit and private not-for-profit (e.g., religious) hospitals and health centres
Local or peripheral level – health posts, health centres providing basic level of care

**

Informal – use of ICT for health purposes in the absence of formal processes and policies
Pilot – testing and evaluating a programme
Established – an ongoing programme that has been conducted for a minimum of 2 years and is planned to continue.

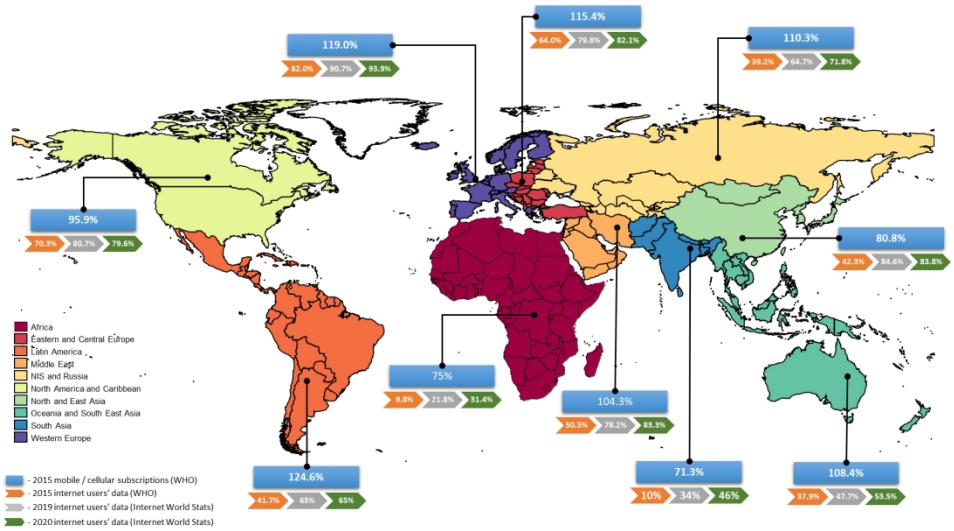


Figure 1

84x47mm (603 x 603 DPI)

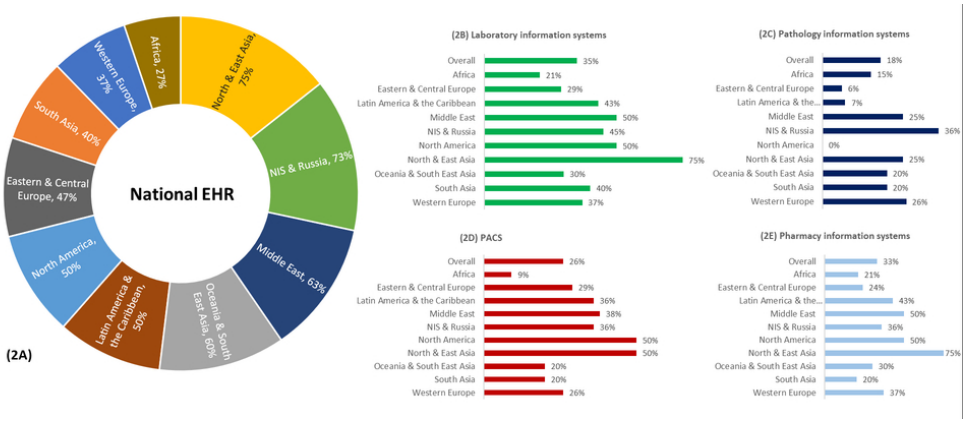


Figure 2

83x34mm (300 x 300 DPI)

Supplementary Materials:

Supplementary Table S1: List of participating countries by ISN regions

Africa		EC Europe	Latin America	Middle East	NIS & Russia	North America	North East Asia	OSEA	South Asia	Western Europe
Benin	Cabo Verde	Moldova	El Salvador	Syrian Arab Republic	Armenia	Jamaica	Korea, Dem. People's Rep.	Cambodia	Afghanistan	Austria
Burkina Faso	Cote d'Ivoire	Albania	Guatemala	Iran, Islamic Rep.	Georgia	Canada	China	Kiribati	Bangladesh	Belgium
Burundi	Ghana	Bosnia and Herzegovina	Honduras	Iraq	Kyrgyz Republic	Trinidad and Tobago	Mongolia	Lao PDR	Bhutan	Denmark
Central African Republic	Kenya	Bulgaria	Colombia	Jordan	Tajikistan	United States	Japan	Philippines	Pakistan	Finland
Comoros	Lesotho	Montenegro	Costa Rica	Lebanon	Ukraine			Timor-Leste	Maldives	Greece
Ethiopia	Mauritania	Romania	Cuba	Bahrain	Uzbekistan			Vietnam		Iceland
Gambia, The	Morocco	Serbia	Dominican Republic	Oman	Azerbaijan			Malaysia		Ireland
Guinea-Bissau	Senegal	Turkey	Mexico	Qatar	Belarus			Australia		Israel
Madagascar	Sudan	Croatia	Panama		Kazakhstan			New Zealand		Italy
Malawi	Zambia	Cyprus	Paraguay		Russian Federation			Singapore		Luxembourg
Mali	Algeria	Czech Republic	Peru		Turkmenistan					Malta
Niger	Botswana	Estonia	Argentina							Netherlands
Rwanda	Equatorial Guinea	Hungary	Chile							Norway
Somalia	South Africa	Latvia	Uruguay							Portugal
South Sudan	Tunisia	Lithuania								San Marino
Uganda	Seychelles	Poland								Spain
Zimbabwe		Slovenia								Sweden
										Switzerland
										United Kingdom

OSEA – Oceania and South-East Asia; NIS – Newly Independent States; PDR – Peoples Democratic Republic; EC Europe – East and Central Europe

Supplementary Table S2: mHealth for accessing services [n (%)]

	Toll-free emergency						Appointment reminders						Treatment adherence					
	International	Regional	National	Intermediate	Local or peripheral level	No Response	International	Regional	National	Intermediate	Local or peripheral level	No Response	International	Regional	National	Intermediate	Local or peripheral level	No Response
Overall	3(2)	9(7)	75(60)	20(16)	18(14)	31(25)	0(0)	8(6)	39(31)	22(18)	38(30)	39(31)	1(1)	7(6)	15(12)	23(18)	35(28)	65(52)
ISN regions:																		
-Africa	0(0)	1(3)	16(48)	6(18)	4(12)	13(39)	0(0)	4(12)	12(36)	5(15)	8(24)	13(39)	1(3)	4(12)	6(18)	5(15)	9(27)	19(58)
-Eastern & Central Europe	0(0)	0(0)	9(53)	1(6)	1(6)	6(35)	0(0)	0(0)	6(35)	0(0)	6(35)	5(29)	0(0)	0(0)	2(12)	3(18)	4(24)	8(47)
-Latin America & the Caribbean	0(0)	1(7)	11(79)	4(29)	4(29)	0(0)	0(0)	1(7)	7(50)	2(14)	3(21)	3(21)	0(0)	0(0)	1(7)	4(29)	3(21)	7(50)
-Middle East	0(0)	0(0)	6(75)	0(0)	1(13)	1(13)	0(0)	0(0)	4(50)	3(38)	1(13)	1(13)	0(0)	0(0)	0(0)	1(13)	0(0)	7(88)
-NIS & Russia	0(0)	3(27)	5(45)	3(27)	3(27)	2(18)	0(0)	1(9)	1(9)	1(9)	4(36)	4(36)	0(0)	1(9)	1(9)	1(9)	4(36)	5(45)
-North America	0(0)	0(0)	4(100)	1(25)	1(25)	0(0)	0(0)	0(0)	0(0)	1(25)	2(50)	2(50)	0(0)	0(0)	0(0)	2(50)	2(50)	1(25)
-North and East Asia	0(0)	0(0)	2(50)	2(50)	1(25)	1(25)	0(0)	0(0)	0(0)	0(0)	3(75)	1(25)	0(0)	0(0)	0(0)	0(0)	1(25)	3(75)
-Oceania & South East Asia	1(10)	1(10)	8(80)	1(10)	2(20)	2(20)	0(0)	0(0)	2(20)	5(50)	3(30)	4(40)	0(0)	0(0)	1(10)	3(30)	4(40)	5(50)
-South Asia	0(0)	0(0)	1(20)	1(20)	0(0)	3(60)	0(0)	0(0)	1(20)	2(40)	2(40)	2(40)	0(0)	1(20)	2(40)	2(40)	1(20)	2(40)
-Western Europe	2(11)	3(16)	13(68)	1(5)	1(5)	3(16)	0(0)	2(11)	6(32)	3(16)	6(32)	4(21)	0(0)	1(5)	2(11)	2(11)	7(37)	8(42)
World Bank Groups:																		
-Low income	0(0)	1(5)	8(42)	3(16)	2(11)	9(47)	0(0)	2(11)	5(26)	4(21)	6(32)	7(37)	0(0)	2(11)	4(21)	4(21)	4(21)	11(58)
-Lower-middle income	1(3)	3(10)	18(60)	5(17)	6(20)	6(20)	0(0)	2(7)	12(40)	6(20)	8(27)	11(37)	1(3)	2(7)	5(17)	5(17)	9(30)	17(57)
-Upper-middle income	0(0)	0(0)	17(50)	8(24)	6(18)	10(29)	0(0)	1(3)	8(24)	5(15)	8(24)	14(41)	0(0)	2(6)	3(9)	3(9)	8(24)	20(59)
-High income	2(5)	5(12)	32(76)	4(10)	4(10)	6(14)	0(0)	3(7)	14(33)	7(17)	16(38)	7(17)	0(0)	1(2)	3(7)	11(26)	14(33)	17(40)

Figure S1: National eHealth policies / strategies across ISN regions

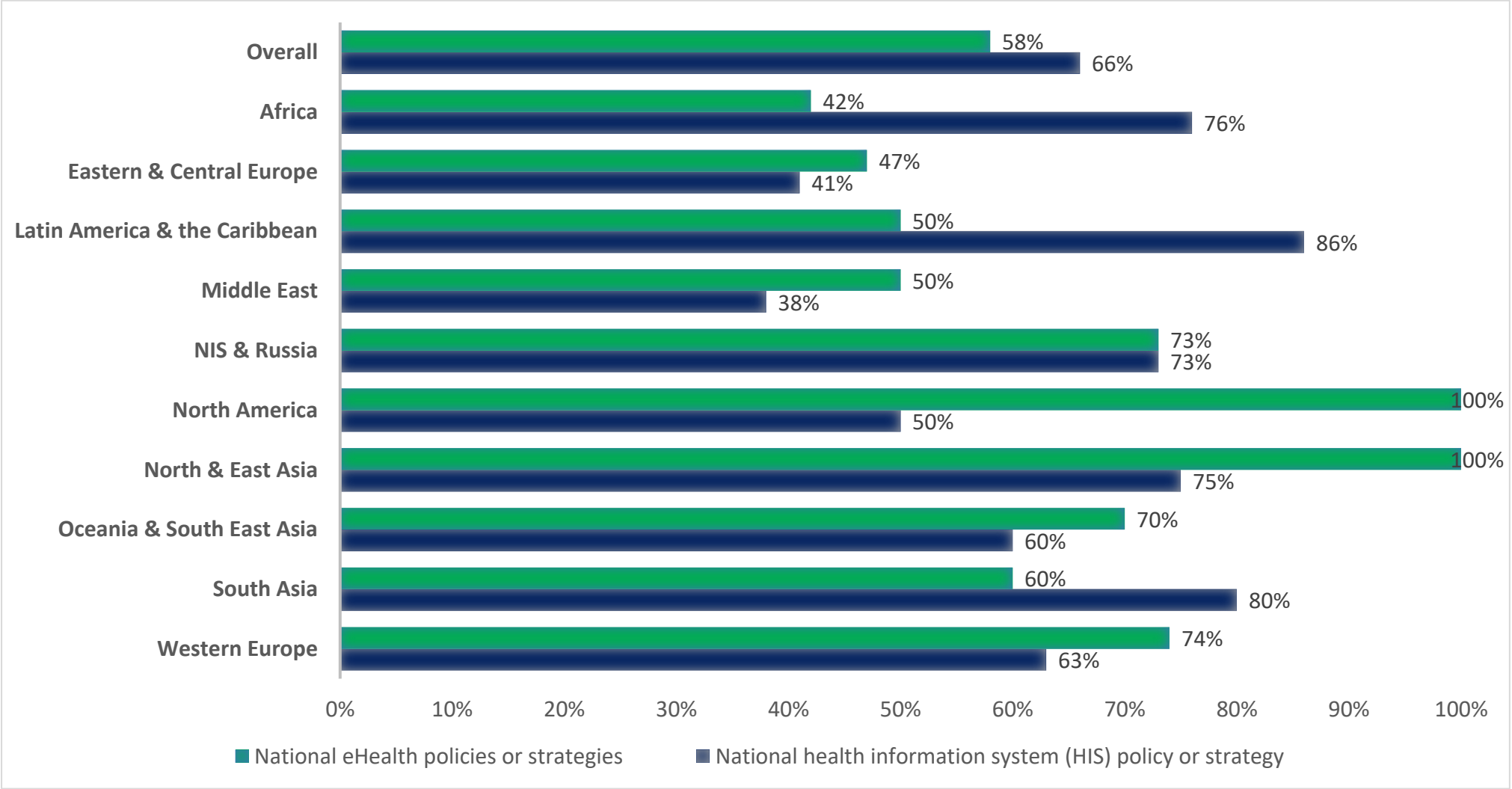


Figure S2: Funding sources for eHealth by income groups

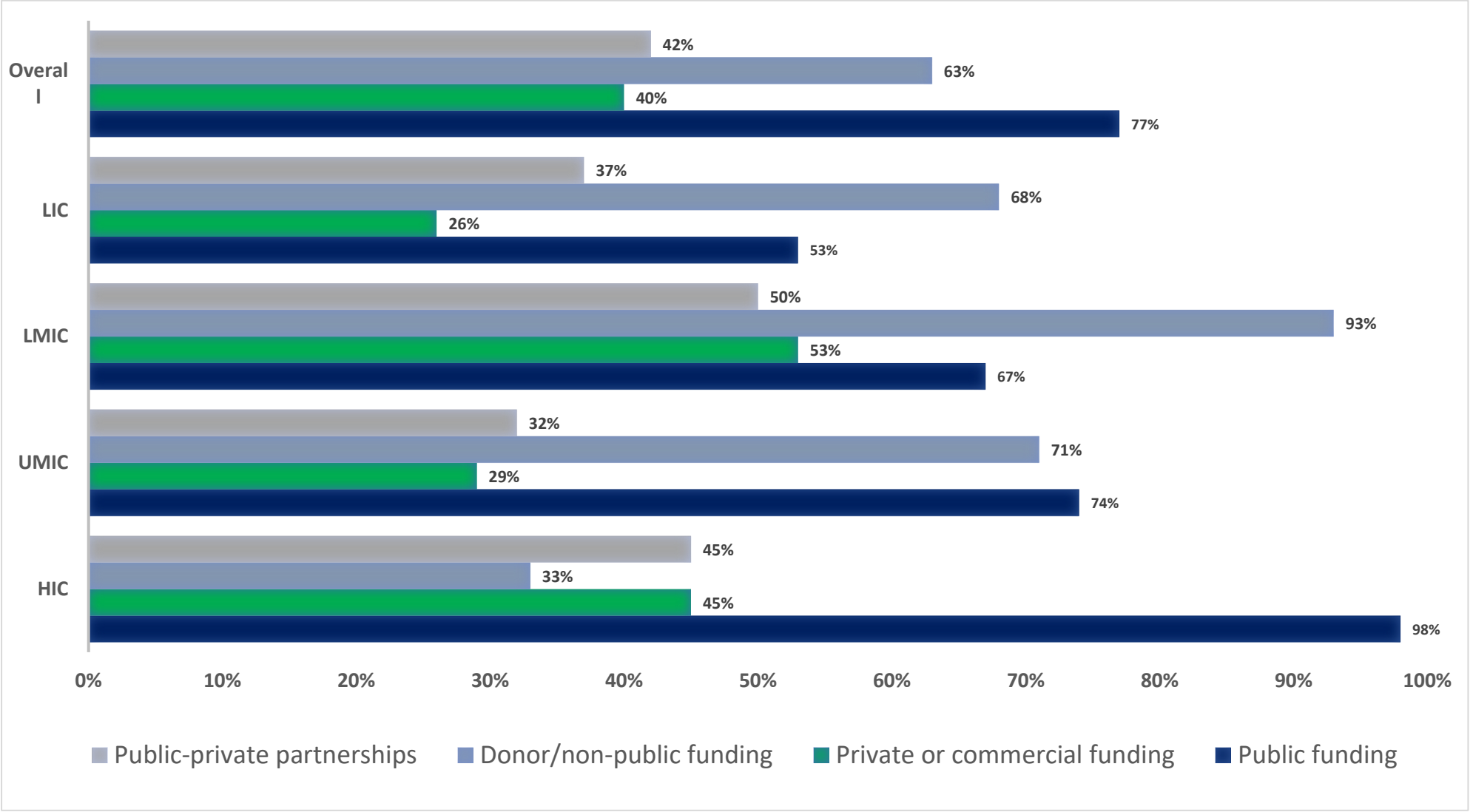


Figure S3: eHealth capacity building

Figure S4: Use of e-learning in health sciences by income groups

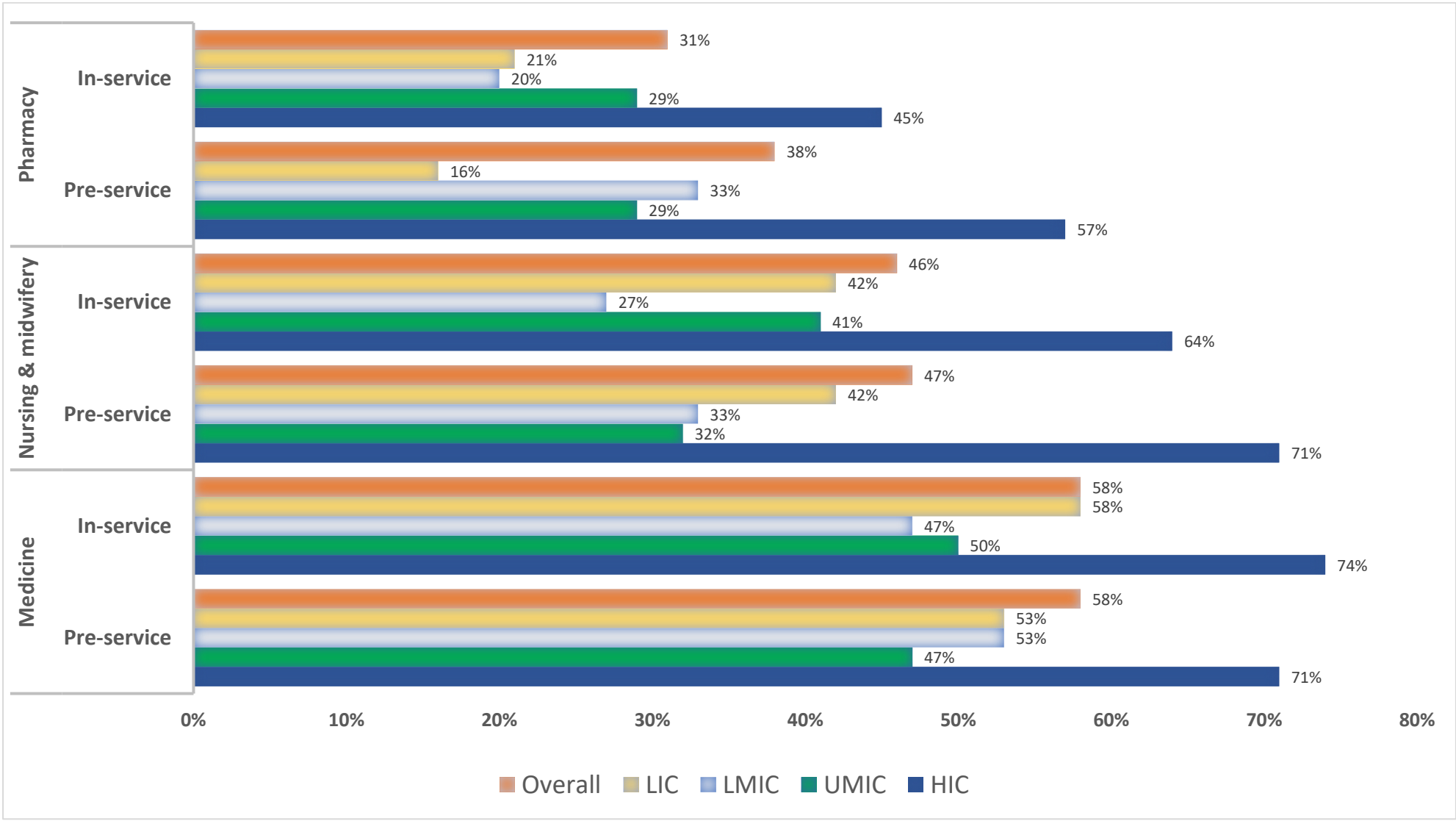


Figure S5: Health facilities with EHR in ISN regions

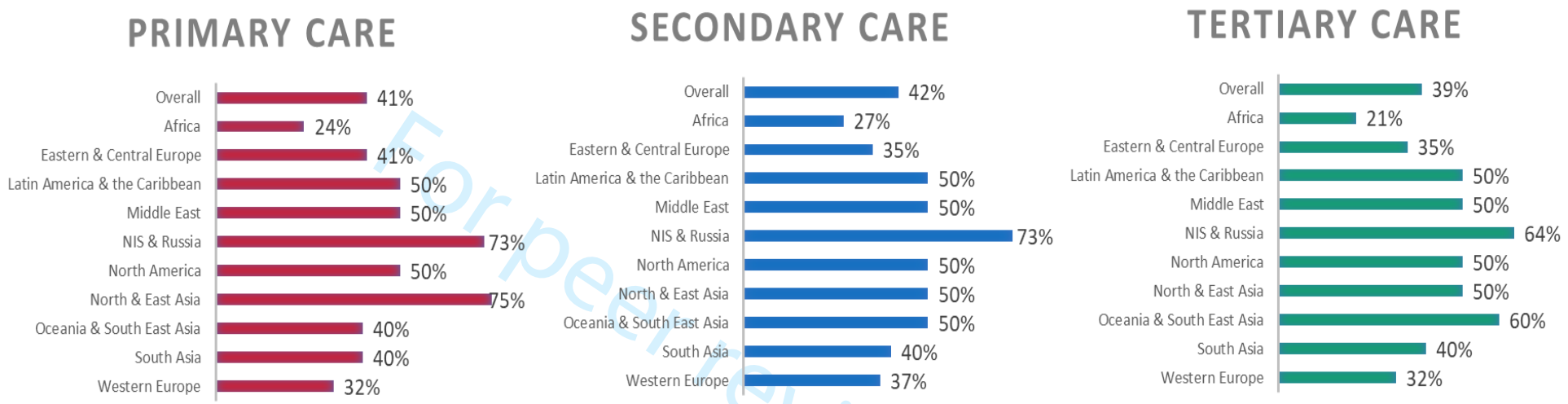


Figure S6: Availability of human resources for Health Information Systems

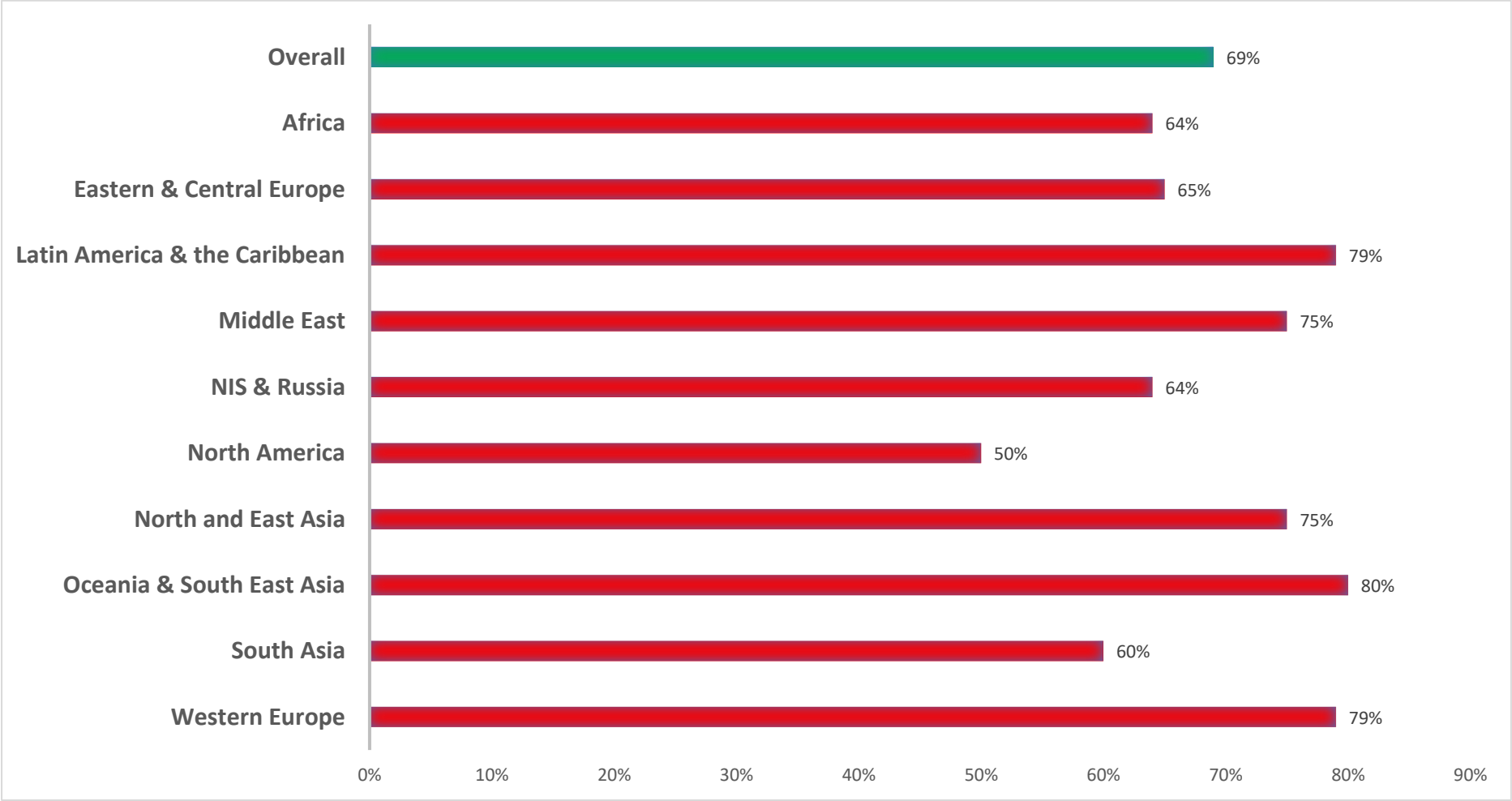


Figure S7: Legal framework for eHealth across income groups

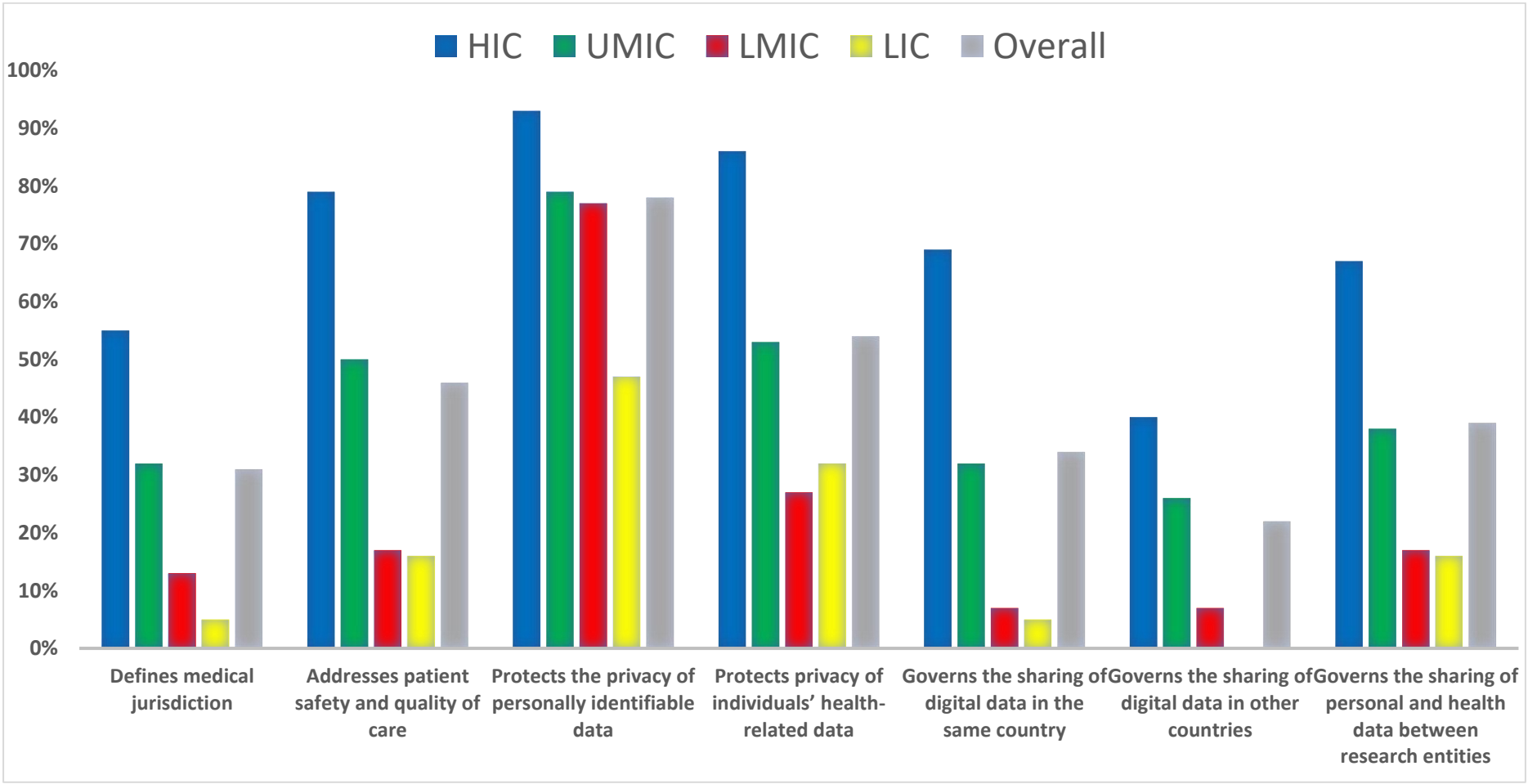


Figure S8: Health care organizations use of social media across ISN regions

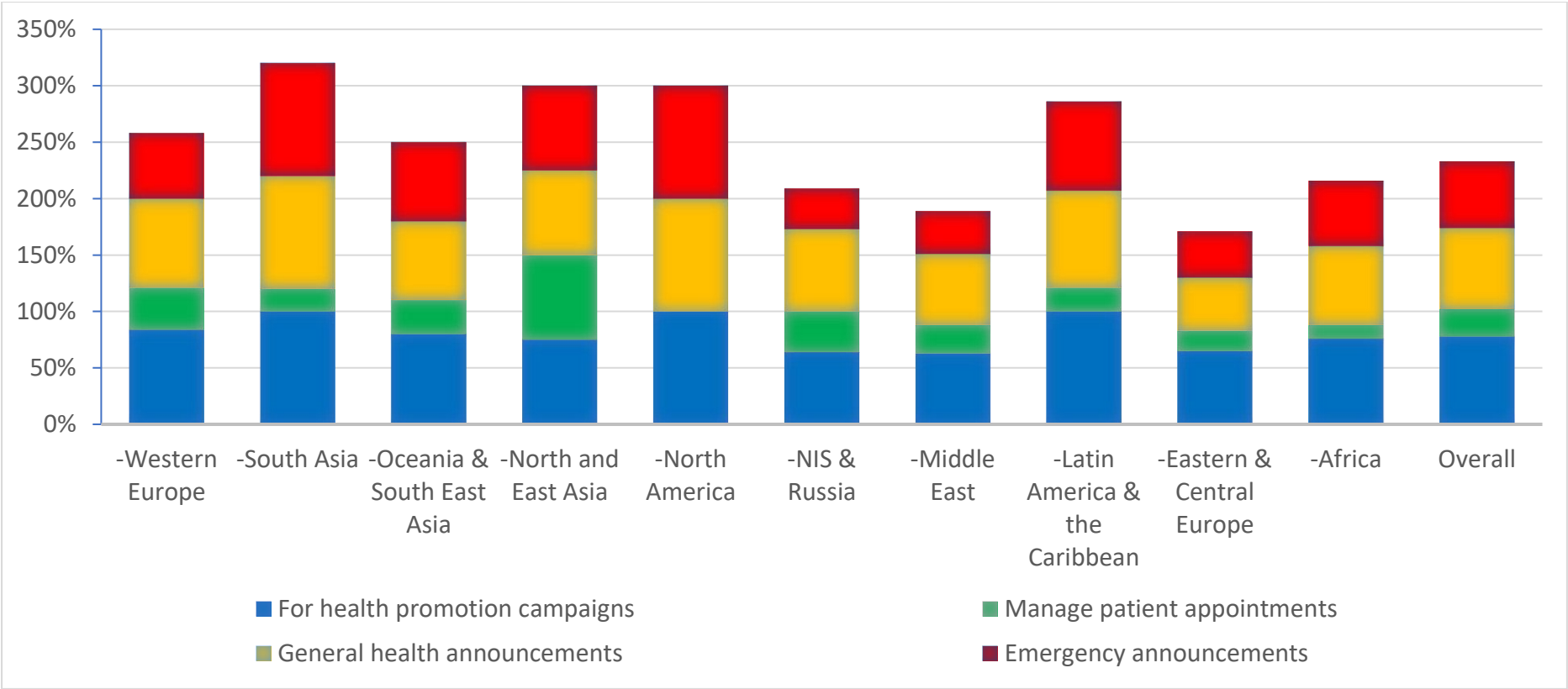
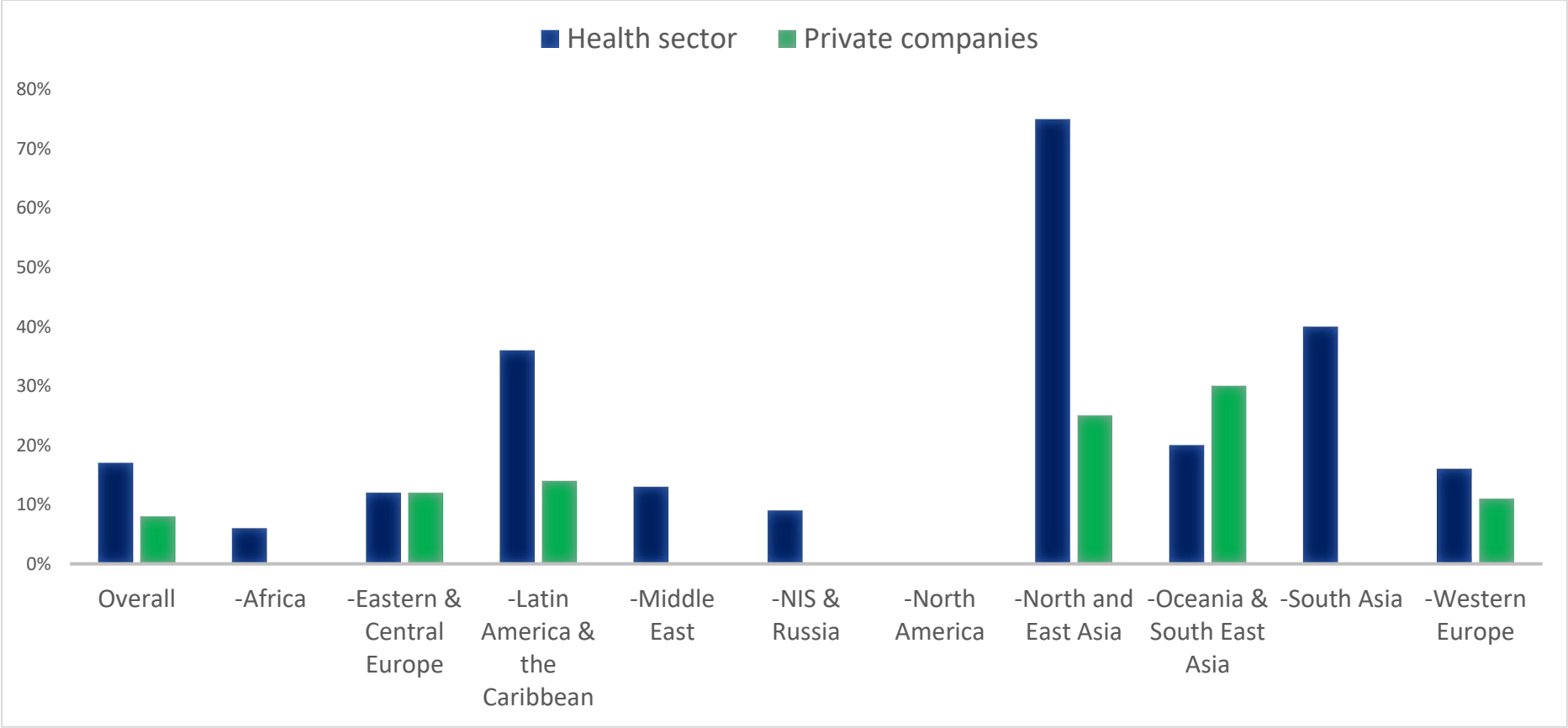


Figure S9: Policy / strategy governing the use of big data



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Global eHealth Capacity: Secondary Analysis of WHO data on eHealth and Implications for Kidney Care Delivery in Low Resource Settings.

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Title: Global eHealth Capacity: Secondary Analysis of WHO data on eHealth and Implications for Kidney Care Delivery in Low Resource Settings.

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Abstract

Objective: To describe the use of electronic health (eHealth) in support of health coverage for kidney care across International Society of Nephrology (ISN) regions.

Design: Secondary analysis of World Health Organization (WHO) survey on eHealth as well as use of data from the World Bank, and Internet World Stats on global eHealth services.

Setting: A web-based survey on the use of eHealth in support of universal health coverage

Participants: 125 WHO Member States provided response.

Primary outcome measures: The availability of eHealth services (e.g., electronic health records, telehealth, etc) and governance frameworks (policies) for kidney care across ISN regions.

Results: The survey conducted by the WHO received responses from 125 (64.4%) Member States representing 4.4 billion people globally. The number of mobile cellular subscriptions were < 100% of the population in Africa, South Asia, North America, and North-East Asia; percentage of internet users increased from 2015 to 2020 in all regions. Western Europe had the highest percentage of internet users in all the periods: 2015 (82.0%), 2019 (90.7%), and 2020 (93.9%); Africa had the least: 9.8%, 21.8% and 31.4%, respectively. The North-East Asia region had the highest availability of national electronic health record system (75%) and eLearning access in medical schools (100%) with the lowest in Africa (27% and 39%, respectively). Policies concerning governance aspects of eHealth (e.g. privacy, liability, data sharing) were more widely available in high-income countries (55% to 93%) than in low-income countries (0% to 47%) while access to mHealth for treatment adherence was more available in low-income countries (21%) than in high-income countries (7%).

Conclusion: The penetration of eHealth services across ISN regions is suboptimal, particularly in low-income countries. Increasing utilization of internet communication technologies provides an opportunity to improve access to kidney education and care globally, especially in low-income countries.

Strengths and Limitations of this study:

- This is the first study assessing the availability and use of eHealth services across International Society of Nephrology (ISN) regions using global data on eHealth availability and use.
- Data were collected by the World Health Organization (WHO) through a web-based survey to evaluate the availability of eHealth across eight themes: eHealth foundations, mobile health (mHealth), telehealth, eLearning, electronic health records, legal frameworks for eHealth, social media, and big data.
- Lack of policy and governance strategies relevant to eHealth (e.g., privacy, liability, data sharing / ownership), as well as poor utilization of eHealth for learning and health information systems remains a major hurdle to achieving universal health coverage, especially in low- and lower-middle income countries.
- The findings of this study can be used to improve workforce shortages for learning, training, and delivery of kidney care, especially in low resource settings.
- A limitation of this work may relate to the non-participation in the survey used for our study of a few countries with large populations in their regions.

Introduction:

Approximately 97% of people worldwide live within reach of a mobile cellular signal.[1] The widespread availability of this service can be a platform for increased utilization of registries, electronic health records and diseases surveillance systems to empower monitoring and reporting of disease incidence and prevalence,[2] patient outcomes,[3] and quality and safety of delivered care[3,4] as well as to allow comparison between and within health services.[5-7] Electronic health (eHealth) is the cost-effective and secure use of information and communications technologies (ICT) in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research.[8] According to the World Health Organization (WHO), 87% of Member States have one or more national mHealth initiatives, 58% have an effective strategy for eHealth, 55% have legislation to protect electronic patient data.[8]

In the current era of the COVID-19 global pandemic, the potential for using eHealth to transform kidney disease management is increasingly recognized.[9,10] A cross-sectional survey conducted by the International Society of Nephrology (ISN) Global Kidney Health Atlas (GKHA) in 2017 reported low utilization of health information systems in the care of patients with kidney failure, especially in low-income countries (LICs) and lower-middle-income countries (LMICs).[11] However, the survey was limited by a focus on registries.[11] Furthermore, a systematic review of 43 studies that included 6,617 participants and evaluated the impact of an eHealth intervention in people with chronic kidney disease (CKD) did not find statistically significant improvements in the health domains assessed with eHealth in patients with CKD although eHealth was suggested to be useful for dietary sodium intake and fluid management.[12] However, other studies have shown that some forms of eHealth (e.g., telenephrology) are useful for improving access to kidney care in primary care settings,[13] for

self-management for patients with CKD,[14] for nurse practitioner and nephrologist training and education,[15,16] and for safe, economical and efficient care delivery in rural and remote areas.[17] The aim of this study is to secondarily analyse available WHO data on eHealth across eight themes (eHealth foundations, mobile health (mHealth), telehealth, eLearning, electronic health records, legal frameworks for eHealth, social media, and big data) for universal health coverage[18] and appraise the implications of our findings for kidney care across ISN regions.

Methods

This study is a secondary analysis of data from the WHO third global survey on eHealth.[18] The study, which was designed using a survey method is summarized as follows. The cross-sectional survey was developed and conducted by the WHO through the Global Observatory for eHealth (GOe) with input and consultation from experts in eHealth. The survey assessed eight themes in eHealth including: (i) eHealth foundations, (ii) mobile health (mHealth), (iii) telehealth, (iv) eLearning, (v) electronic health records (EHR), (vi) legal frameworks for eHealth, (vii) social media and (viii) big data. Concise definitions of these themes are provided:

- **eHealth:**[19] the cost-effective and secure use of ICT in support of health and health related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research.
- **mHealth:**[18] the use of mobile devices, such as mobile phones, patient monitoring devices, Personal Digital Assistants, and wireless devices, for medical and public health practice including free telephone hotlines for emergencies provided by trained personnel and pre-recorded messages (toll-free emergency telephone services), reminder messages provided by health services to patients aimed at achieving

medication adherence, reminder messages to patients to make or attend an appointment, etc..

- **Telehealth:**[18] the delivery of health care services through ICT for the exchange of information in real time (synchronously, e.g., by telephone or video link) or by store-and-forward methods (asynchronously, e.g., by email) for the diagnosis and treatment of diseases and injuries, research and evaluation, and for the continuing education of health professionals where patients and care providers are separated by distance.
- **eLearning:**[20] the use of ICT for education
- **Electronic Health Records (EHR):**[18] real-time, patient-centred records that provide immediate and secure information to authorized users and typically contain a patient's medical history, diagnoses and treatment, medications, allergies, immunizations, as well as radiology images and laboratory results.
- **Legal framework for eHealth:**[18] the legislative process addressing transfer and use of information between health care workers and patients that is relevant to issues of privacy and confidentiality of patient data, access rights and sharing rights for data, addressing data quality and integrity as a basis for clinical and patient decision-making and rules governing the adaptation of professional liability to accommodate care provided remotely or virtually.
- **Social Media:**[18] interactive platforms for individuals, communities and organizations to share and discuss content, debate issues and promote new ideas e.g. Facebook, Twitter or YouTube.
- **Big data:**[18] refers to extremely large data sets that encompass a range of data including clinical data from electronic health records; the phenotype; genomic information; and data on other determinants of health such as environment and lifestyle.

The survey was developed in English and translated into seven languages (Arabic, Chinese, English, French, Russian, Spanish and Portuguese) to improve country responses and accuracy of responses. A web-based tool, (LimeSurvey - https://www.limesurvey.org/en/), was used for online form creation, data collection and management. WHO regional offices staff assisted in coordinating the survey process and liaising with the GOe Secretariat in Geneva. National level survey coordinators, together with relevant ministries and academic and research institutions identified between 5 and 10 national expert informant groups in eHealth to participate in the survey. The group consisted of eHealth specialists, professionals in telehealth, EHRs, mHealth and statisticians responsible for national health data. Expert informants met for one day to reach consensus on a single national-level response. Hence, each participating country submitted a single national survey with input from its group of expert informants. The survey was conducted between 1 April and 30 June 2015. Data on ICT indices (a composite index of fixed-telephone subscriptions, mobile-cellular telephone subscriptions, international Internet bandwidth per Internet user, households with a computer, and households with Internet access; scored as low as 0 to as high as 100 and presented in unit scores) were obtained from the World Bank[21] while more recent (2019 and 2020) data on internet usage were obtained from Internet World Stats (https://www.internetworldstats.com/).

Data handling and processing

The results of the survey were reported according to the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) statement[22] (Supplementary Appendix). After receiving the completed questionnaires, all non-English responses were translated into English and survey responses were checked for consistency. Data were then analyzed by

thematic sections using computed percentages for each "yes" response to obtain the overall results for all responding countries and regions. We regrouped country responses using the ten ISN regional classification: Africa, East and Central Europe, Latin America, Middle East, Newly Independent States (NIS) and Russia, North America and Caribbean, North and East Asia, Oceania and South East Asia (OSEA), South Asia and Western Europe (https://www.theisn.org/about-isn/governance/regional-boards/). Country responses were also grouped according to World Bank income groups. Data on mobile-cellular subscriptions and internet users in each region were provided as the median percentage of the total population of participating regions. No statistical comparisons were used for describing the data which were presented in percentages.

Patient and public involvement:

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Results

(i) Participating country indices

A response to the survey was received from 125 WHO Member States out of 194 Member States that were surveyed, representing a response rate of 64.4% and a total population of 4.39 billion people. The list of participating countries based on ISN reginal groups is presented in Supplementary Table S1 and a summary of the demographic, economic and health metrics for each region is shown in Table 1. Overall, the median ICT development index for participating countries was 4.8 (95% CI: 2.9-6.9). Four regions: Africa (2.3), South Asia (2.3), OSEA (4.0) and Latin America (4.4) had lower indices compared to the median value while Western Europe had the highest (7.9). Subscriptions to mobile-

cellular networks was highest in the Latin America region (124.6% [95% CI: 89.9 – 142.7]) and lowest in South Asia (71.3% [95% CI: 63.7 – 120.6]) while percentage of the population that used the internet was highest in Western Europe (82.0% [95% CI: 70.0 – 93.0]) and lowest in Africa (9.8% [95% CI: 3.0 – 18.1]) (Figure 1). However, internet users increased across all regions in 2019 and 2020, including Africa (21.8% and 31.4%, respectively) and South Asia (34% and 46%, respectively) (Figure 1).

(ii) National eHealth policies, funding and capacity building

A national policy for eHealth was available in all participating countries in North America (100%) and North East Asia (100%) and was lowest in participating countries from Africa (42%) and East and Central European countries (47%) (Figure S1). Availability of policies governing health information systems in countries across regions also varied across regions. Overall, participating countries reported multiple sources of funding for eHealth including public (77%), donor (non-public) (63%), private (commercial) (40%) and public-private partnerships (42%) and LICs and LMICs relied more on donor funding for eHealth services (Figure S2). Overall, pre-service, and in-service training in eHealth were available in 74% and 77%, respectively. Pre-service training was lowest in Africa (55%) and highest in NIS and Russia (100%) and North America (100%). In-service training was lowest in Africa (58%) and highest in North and East Asia (100%) (Figure S3).

(iii) mHealth

Data on access to mHealth across 3 of the 6 domains reported (toll-free emergency, appointment reminders and treatment adherence) are provided in Supplementary Table S2. International toll-free emergency access to mHealth was available in only 2 regions: OSEA (10%) and Western Europe (11%) and was unavailable in all regions for appointment

reminders. National toll-free emergency access to mHealth services was variably available in all regions. Access to National mHealth services for treatment adherence was mostly available in low-income countries (21%) and was lowest in high-income countries (HICs) (7%).

(iv) Telehealth

Teledermatology, telepathology, teleradiology and telepsychiatry were reported but telenephrology programs were not reported. Nonetheless, services to remote patient monitoring were mostly available in HICs (40%) and at the local / peripheral health care system level with the program fully established only in 26% of countries (Table 2).

(v) eLearning

The availability of eLearning for health sciences students (pre-service) and health professionals (in-service) in Medicine (Medical School), nursing and midwifery and pharmacy are reported in Figure S4. Use of eLearning in Medical school was highest in North East Asia (100%) and lowest in South Asia (40%) and Africa (39%). North East Asia also had the highest use of eLearning services for pre-service training of nurses and midwives (75%) and pharmacists (100%). Use of eLearning for pharmacists training was unavailable in South Asia (Figure S4).

(vi) Electronic health records (EHR) systems

National EHR systems were mostly available in in North East Asia (75%) while countries in Africa had the least availability of EHR systems (27%) (Figure 2A). Overall, secondary healthcare facilities were more likely to have EHR systems (42%) than primary healthcare (41%) or tertiary healthcare facilities (39%) (Figure S5). Secondary and tertiary

facilities in the NIS and Russia region had the highest availability of EHR systems (73% and 64%, respectively) while all tiers of healthcare facilities in Africa had the lowest (Figure S5). Availability of laboratory information systems, pathology information systems, picture archiving and communication system (PACS) and pharmacy information systems by income groups are shown in Figures 2B-2E with most regions reporting low availability of these systems for healthcare. Human resource availability for health information systems was similar across income groups but was highest in the Oceania and the South East Asia region (80%) (Figure S6).

(vii) Legal frameworks for eHealth

Aspects of the legal framework governing use of eHealth were not readily available across countries and regions (Figure S7). For instance, countries from the South Asia region, did not have frameworks governing liability or reimbursement for eHealth, patient safety and quality of care based on data quality, protection of the privacy of individuals, sharing of digital data between health professionals and sharing of personal health data between research entities (Figure S7).

(viii) Social media

National policy on use of social media by government organizations was lacking and ranged from as low as 9% in the NIS and Russia region to 50% in the North East Asia region. However, specific policy on the use of social media in the health domain was unavailable in six regions (Eastern and Central Europe, Latin America, Middle East, NIS & Russia, North America and South Asia). When utilized, social media were mostly used for making emergency announcements, general health announcements and for health promotion campaigns (Figure S8).

(ix) Big data

Information on policy or strategies that govern use of big data in the health sector and private companies was sparsely reported. North East Asia had the highest proportion of policies in the health sector (75%) whilst Africa had the least (6%). No data was obtained for North America. (Figure S9).

Discussion

The United Nations Sustainable Development Goals emphasizes the great potential of the spread of information and communications technology and global interconnectedness to accelerate human progress, and to bridge the digital divide to develop knowledge in societies.[23] The ISN-GKHA has identified large and varied gaps in resources and workforce required for adequate provision of kidney care across several countries, particularly in LICs and LMICs in all the ISN regions. eHealth services may be potential vehicle to harness local resources for improvements in kidney care. This study, which mainly analyzed WHO eHealth survey data using the ISN regional groups, found low ICT development indices mostly in LIC and LMICs, low availability of national EHR and proportion of national eHealth policies in LICs and LMICs, increased utilization of mHealth services in low-income settings, lack of use of eLearning across regions and absence of legal frameworks governing use of eHealth in several ISN regions. These findings underscore the need for concerted action if eHealth is to achieve its potential for reducing inequities in kidney care across regions and countries.

A major challenge in accessing kidney care in many countries is the lack of skilled workforce, specifically the absence of an adequate number of nephrologists.[24] The nephrologist density in HICs in North America and Western Europe is more than 90 times

that in low-income countries in Africa, South Asia and Oceania region (28.52 per million population [pmp] vs. 0.31 pmp),[25] suggesting a clear disadvantage in care access for populations with low nephrologist densities.[26] In a global survey Lunney et al identified geography and low nephrology workforce to be associated with lack of access to kidney care, especially in low-income countries.[27] Low nephrology workforce, particularly in rural or remote areas often means long travel distance to access care[28] with potentially negative consequences, including increased cost of care, low quality of life,[29] lack of access to kidney replacement therapies (KRT; i.e. dialysis and transplantation)[29-31] and increased likelihood of death.[32] In a large South African Province with only 2 public service nephrologists, a study that assessed the predictors of mortality in rural dwelling patients receiving KRT at a district hospital, found mortality to be higher in PD patients ($P<0.001$) who travelled farther to reach the hospital than those treated with HD.[30] These challenges are not limited to low resource countries. One study from Australia estimated that use of telehealth services for evaluating post-transplant patients resulted in a net saving of 203,202 kilometres in patient travel distance; 2771 hours in car travel time; about AUD $31,048 in petrol savings and 51 tonnes CO_2 equivalents of greenhouse gas emissions.[28] Due to the widespread availability of mobile cellular signals,[1] cellular and internet technologies have potential to improve access to nephrology care in remote and/or underserved settings. Access to care can also be improved in children with kidney diseases given the significant shortage of paediatric nephrologists[33] and mitigate high mortality identified in children with kidney failure in regions such as Africa.[34] The global COVID-19 pandemic demonstrates that use of eHealth technologies will likely increase over the coming years,[35,36] thereby highlighting the need to strengthen governance on how eHealth systems are utilized across ISN regions. Care of patients with CKD has been grossly affected during the pandemic, and it falls upon the stakeholder community to develop sustainable solutions.

The prevalence of CKD risk factors such as hypertension and diabetes mellitus continue to increase globally. The rise is projected to be significant, especially in LICs and LMICs of South and South East Asia and Africa.[37,38] For instance, globally, 79% of people with diabetes live in LICs or LMICs (mostly Oceania, South and South East Asia region) and projections of diabetes prevalence by 2045 suggest an increase of 143% in Africa, 96% in the Middle East and 74% in South East Asia compared with 15% and 33% increase in Europe and North America, respectively.[37] Innovative models of care delivery are therefore needed to manage the growing disease burden. Given the wide coverage of mobile phone networks, mHealth holds promise as an important delivery tool for health care delivery in resource constrained regions (Figure 1). mHealth interventions are in use for diagnosis and management of various infectious diseases including malaria,[39] tuberculosis,[40] and HIV[41] and for improving maternal and foetal health[42] in several developing countries. Although mHealth interventions are increasingly used for non-communicable diseases,[43-45] some studies highlight only a modest impact in NCD control likely due to limited number of studies and impact on process of care alone.[46,47] Our analysis showed that use of mHealth (appointment reminders and treatment adherence) and telehealth services (remote patient monitoring) were much higher in LICs and LMICs than in HICs (Supplementary Table S2 and Table 2). In a study conducted in a rural Indonesian population multifaceted mobile technology–supported primary health care intervention was associated with greater use of preventive CVD medication and lower BP levels among high-risk individuals.[48] These findings suggest that despite the relatively low current use, mHealth may be potentially useful for supporting case-finding for CKD,[49] CKD-specific education to improve awareness, integrated care delivery and efficient referral pathways, and perhaps allow quality control through real-time monitoring.[50]

To guide implementation, ethical issues including type and quality of digital technology, doctor-patient relationship, data confidentiality and security, informed consent and patients and families satisfaction with telemedicine services should be considered in framing legal governance for eHealth.[51] Increasing the use of such technologies will require demonstration of public benefits (e.g. cost saving),[52] while ensuring that there is no discrimination or digital inequality (e.g. not tailored to only those with a smartphone or for the disabled)[53] and to protect patient and data privacy.[54] As our study shows, the legal frameworks that govern sharing of personal health data or digital data and protect the privacy of individual health-related data were either low or absent in many regions. There is need to address such legislation in all regions (Figure S7).

Our study also identified EHR use to be low in LICs and LMICs with poor utilization of eLearning for pre-and in-service training in the health sectors (Figure S5). Barriers that impede adoption and/or implementation of EHR systems such as cost (including setting up, maintenance and ongoing costs), technical concerns, technical support, resistance to changing work habits, loss of income and loss of productivity will need to be identified in each setting and addressed. As Kruse et al[55] have suggested, policy makers will need to consider incentives that reduce the implementation cost of EHR, possibly aimed more directly at organizations that are known to have lower adoption rates, such as small hospitals in rural areas. However, this may be possible in HICs where such technologies are readily available, whereas in LICs and LMICs, such incentives should be targeted towards secondary and tertiary care centres that serve a wider population. Measures that ensure successful adoption and implementation of EHR technology including systems usability, interoperability, and

adaptability need to be considered in terms of local context, individual end-users and advancing technology.[56]

The potential and value of eLearning in addressing workforce shortages[20,57] and the educational needs of health professionals, especially in developing countries is well recognized.[58] The ISN fellowship program recently included hybrid (online plus hands-on) training as part of the strategy for improving training of nephrologists from low-resource settings.[24] This can improve training in glomerular diseases (histopathology), assessment of urine microscopic findings as well as various aspects of interventional nephrology including dialysis catheter insertion and care. A number of groups have used virtual platforms to upskill healthcare workers in the care of patients with COVID-19 in India and Africa.[59] Access to the basic IT infrastructure (e.g. computers and internet) remains a major hurdle to the implementation of technology-enhanced teaching in developing countries.[58] Any solution should be sensitive to local resources and be designed to operate at low cost (data, device). One study that assessed the awareness, attitudes, preferences, and challenges to eLearning among medical and nursing students at Makerere University, Uganda identified low monthly income, quality of internet connectivity and lack of computer ownership among factors that significantly affected attitudes towards eLearning.[60] Perceived advantages of online learning by medical students in the UK included time and money saved from lack of travel and flexibility and ability to learn at one's own pace whereas family distractions, internet connection and the timing of tutorials were identified as barriers.[61] The extent of integration of eLearning in health sciences (Medicine, Nursing and midwifery and Pharmacy) for both pre- and in-service training was low in most regions in our study (Figure S4). The impact of an improved integration of eLearning in health sciences will be widespread across all medical disciplines.

There were a few limitations to this study previously described in the WHO report.[18] These include that the report is old (2015), given that there are no other reports superseding this with a global reach. However, our study has made up for this by the inclusion of newer data from elsewhere showing availability and use of telecommunications services as a proxy for use of eHealth that rely on such services. Also, WHO Member States were limited to one response per country i.e., expert informants were required to propose a consensus response for each question which was difficult in cases where the situation varied widely within the country. Furthermore, although every effort was made to select the best national experts to complete the instrument; the knowledge capacity of each focus group to accurately answer the questions was not determined. Another limitation of this study is the focus on large hospitals and private health institutions as all eHealth capacities and strategies (e.g., primary care level or general practitioner clinics) may not have been adequately captured, thus underestimating its use across countries. However, this data provides a broad scan of the availability of these services across participating countries and regions, therefore useful for monitoring progress and for improving services. Finally, some countries with large populations (e.g., France, Germany, Brazil, Egypt, Nigeria, and India) did not participate in the 2015 survey. This is likely to have affected some of the results of this survey e.g. proportion with access to the internet. Despite the limitations, this study is the first to present a comprehensive overview of the status and penetration of eHealth in ISN regions using data from the WHO global survey on eHealth. Our study has also been able to address identified gaps in availability of eHealth services and the implications of these for kidney care across ISN regions, particularly for LICs and LMICs.

Conclusion:

There is wide variation in the availability and accessibility of eHealth services across ISN regions with much reduced availability and access in LICs and LMICs. This is likely to have a significant negative impact for adequate kidney care provision in these regions, especially at a time when there are global restrictions in face-to-face contacts. Even though much infrastructure is required to set up such services, simple steps can be initiated towards broader use of eHealth services to aid care including legislations and provision of national guidelines / requirements on use of these technologies. Infrastructure development to improve access to the internet will need to be improved across regions especially in low-income countries. With rapidly evolving ICT technologies and as digitalization of medical education and care continues to gather pace in the future of healthcare, further research on the impact of eHealth in care of patients with kidney diseases is critical. The development of and access to appropriate technologies which facilitate equitable and high-quality care are needed to ensure no one is left behind.

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FIGURE LEGENDS

Figure 1: Proportion of mobile-cellular users and internet access across ISN regions

Figure 2(A – E): (A) Availability of national EHR system, (B - E) Availability of other electronic health record systems (laboratory information systems, pathology information systems, PACS systems, and pharmacy information systems)
Abbreviations: EHR – electronic health records, PACS - picture archiving and communication system)

Supplementary Materials:

Table S1: List of participating countries by ISN regions

Table S2: mHealth for accessing services

Figure S1: National eHealth policies / strategies across ISN regions

Figure S2: Funding sources for eHealth by income groups

Figure S3: eHealth capacity building

Figure S4: Use of e-learning in health sciences across ISN regions

Figure S5: Health facilities with EHR in ISN regions

Figure S6: Availability of human resources for Health Information Systems

Figure S7: Legal framework for eHealth across income groups

Figure S8: Health care organizations use of social media across ISN regions

Figure S9: Policy / strategy governing the use of big data

Table 1: Features of participating countries ranked according to ISN regions and World Bank groups

	Total population of participating countries (millions)*	GNI per capita (PPP Int $) *	Physician density (per 10,000 population)	Nurse & midwife density (per 10,000 population)	Hospital bed density (per 10,000 population)	Life expectancy at birth (years)	Total health expenditure (% GDP)	ICT Development Index**
Overall (n=125)	4,389.9	18220 (18722)	1.63 (0.31-3.24)	2.53 (0.74-6.11)	28 (13-49)	74 (66-78)	6.7 (5.4-8.9)	4.8 (2.9-6.9)
ISN regions:								
-Africa (n=33)	600.7	4873 (6190)	0.11 (0.06-0.29)	0.68 (0.42-0.91)	13 (5-20)	60 (57-64)	5.7 (4.4-7.1)	2.3 (1.6-3.7)
-Eastern & Central Europe (n=17)	197.2	18943 (6815)	2.39 (2.02-3.38)	5.50 (4.16-6.27)	54 (39-66)	75 (74-77)	7.2 (5.9-8.0)	6.4 (5.8-6.9)
-Latin America & the Caribbean (n=14)	330.6	12952 (5452)	1.48 (1.11-2.10)	1.04 (0.62-1.51)	14 (10-21)	77 (74-78)	7.3 (6.4-8.8)	4.4 (3.6-6.0)
-Middle East (n=8)	152.3	38863 (40229)	1.95 (0.91-2.88)	2.72 (1.87-5.38)	18 (14-18)	76 (74-78)	5.1 (3.0-7.0)	5.9 (4.7-6.8)
-NIS & Russia (n=11)	278.4	11351 (7072)	3.47 (2.53-3.93)	7.11 (5.02-9.04)	52 (40-87)	69 (69-72)	6.1 (4.5-6.8)	5.3 (5.2-6.4)
-North America (n=4)	359.4	32815 (19823)	1.63 (0.79-2.26)	6.42 (2.33-9.55)	28 (23-31)	77 (73-81)	8.4 (5.7-14.0)	6.6 (4.9-7.9)
-North and East Asia (n=4)	1,548.2	19430 (15835)	2.57 (1.90-3.06)	3.87 (2.64-7.80)	95 (50-135)	73 (69-80)	6.0 (5.6-10.3)	4.8 (4.5-8.3)
-Oceania & South East Asia (n=10)	276.2	20210 (24142)	1.17 (0.18-1.95)	3.50 (1.11-6.00)	23 (14-31)	74 (67-82)	5.3 (4.0-9.4)	4.0 (2.8-7.9)
-South Asia (n=5)	370.4	5366 (3238)	0.36 (0.27-0.83)	0.57 (0.50-0.98)	6 (4-18)	68 (66-71)	3.7 (3.6-8.1)	2.3 (2.2-3.1)
-Western Europe (n=19)	276.6	40262 (11395)	3.49 (3.15-4.10)	8.80 (4.96-15.20)	46 (33-56)	81 (81-82)	9.4 (8.9-10.6)	7.9 (7.5-8.5)
World Bank Groups:								
-Low income (n=19)	353.6	1390 (429)	0.07 (0.04-0.12)	0.53 (0.26-0.77)	10 (4-17)	59 (56-62)	6.2 (4.8-8.1)	1.6 (1.3-1.9)
-Lower-middle income (n=30)	899.9	4816 (2102)	0.38 (0.17-1.60)	0.90 (0.62-3.71)	14 (7-31)	69 (64-72)	5.8 (4.2-6.9)	3.1 (2.4-4.0)
-Upper-middle income (n=34)	2,200.5	14547 (4236)	1.49 (1.15-2.56)	3.28 (1.41-5.41)	27 (17-54)	74 (72-76)	6.3 (5.4-7.2)	4.7 (4.4-5.9)
-High income (n=42)	936.0	38213 (19296)	3.27 (2.43-3.78)	6.27 (4.46-10.86)	38 (32-56)	81 (77-82)	8.9 (6.7-9.7)	7.5 (6.8-8.1)

* - data expressed as mean (SD); all other data represent median and interquartile ranges (IQR)
§ - (per 10,000 population)
** - Data from the World Bank (2015)
GNI – gross national income; PPP – purchasing power parity; GDP – gross domestic product; ICT – Information and communications technology

Table 2: Remote patient monitoring [n (%)]

	Health system level*						Programme type**			
	International	Regional	National	Intermediate	Local or peripheral level	No response	Informal	Pilot	Established	No response
Overall (n=125)	4(3)	4(3)	19(15)	21(17)	28(22)	65(52)	12(10)	38(30)	15(12)	67(54)
ISN regions:										
-Africa (n=33)	2(6)	0(0)	3(9)	2(6)	4(12)	25(76)	2(6)	5(15)	1(3)	25(76)
-Eastern & Central Europe (n=17)	1(6)	1(6)	3(18)	2(12)	5(29)	6(35)	2(12)	9(53)	0(0)	6(35)
-Latin America & the Caribbean (n=14)	0(0)	0(0)	1(7)	1(7)	4(29)	9(64)	1(7)	4(29)	1(7)	9(64)
-Middle East (n=8)	0(0)	0(0)	0(0)	2(25)	1(13)	5(63)	1(13)	1(13)	1(13)	5(63)
-NIS & Russia (n=11)	0(0)	1(9)	2(18)	3(27)	2(18)	5(45)	3(27)	3(27)	1(9)	5(45)
-North America (n=4)	0(0)	0(0)	0(0)	2(50)	1(25)	2(50)	0(0)	1(25)	1(25)	3(75)
-North and East Asia (n=4)	0(0)	0(0)	2(50)	0(0)	1(25)	1(25)	0(0)	1(25)	1(25)	2(50)
-Oceania & South East Asia (n=10)	0(0)	0(0)	0(0)	0(0)	3(30)	7(70)	0(0)	3(30)	0(0)	7(70)
-South Asia (n=5)	1(20)	0(0)	1(20)	1(20)	0(0)	2(40)	0(0)	2(40)	1(20)	2(40)
-Western Europe (n=19)	0(0)	2(11)	7(37)	8(42)	7(37)	3(16)	3(16)	9(47)	8(42)	3(16)
World Bank Groups:										
-Low income (n=19)	0(0)	0(0)	3(16)	1(5)	2(11)	13(68)	1(5)	3(16)	1(5)	14(74)
-Lower-middle income (n=30)	2(7)	1(3)	3(10)	3(10)	3(10)	21(70)	3(10)	6(20)	1(3)	21(70)
-Upper-middle income (n=34)	0(0)	0(0)	3(9)	4(12)	6(18)	22(65)	2(6)	9(26)	2(6)	22(65)
-High income (n=42)	2(5)	3(7)	10(24)	13(31)	17(40)	9(21)	6(14)	20(48)	11(26)	10(24)

*

International level – health entities in other countries in the world
Regional level – health entities in countries in the same geographic region
National level – referral hospitals, laboratories, and health institutes
Intermediate level, covering district or provincial facilities – public, private for-profit and private not-for-profit (e.g., religious) hospitals and health centres
Local or peripheral level – health posts, health centres providing basic level of care

**

Informal – use of ICT for health purposes in the absence of formal processes and policies
Pilot – testing and evaluating a programme
Established – an ongoing programme that has been conducted for a minimum of 2 years and is planned to continue.

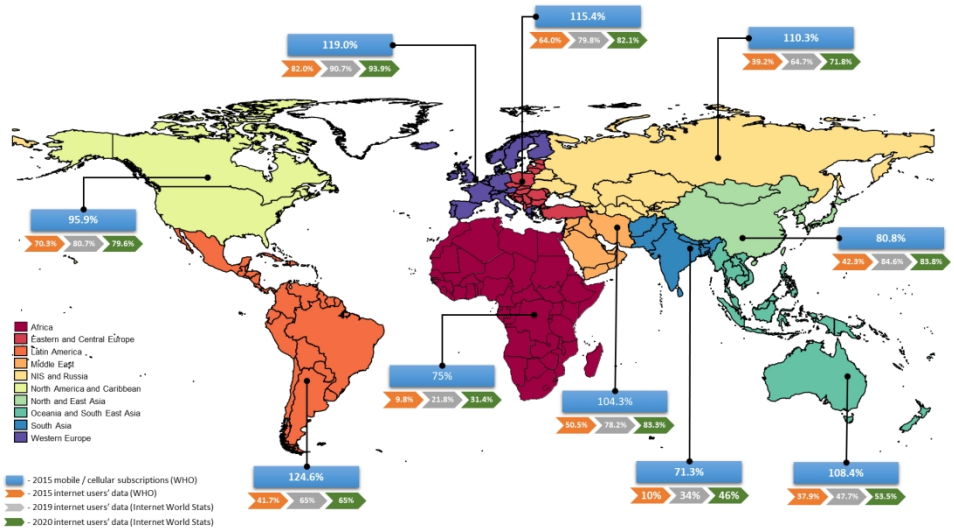

Figure 1

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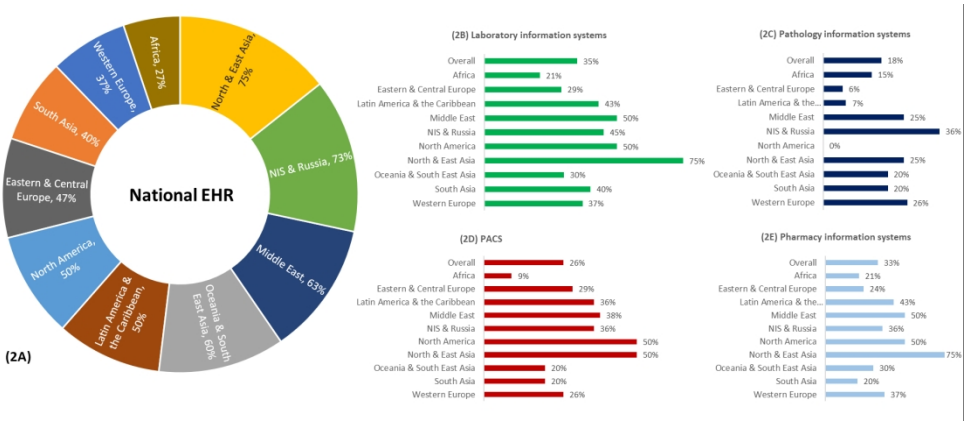

Figure 2

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Supplementary Materials:

Supplementary Table S1: List of participating countries by ISN regions

Africa		EC Europe	Latin America	Middle East	NIS & Russia	North America	North East Asia	OSEA	South Asia	Western Europe
Benin	Cabo Verde	Moldova	El Salvador	Syrian Arab Republic	Armenia	Jamaica	Korea, Dem. People's Rep.	Cambodia	Afghanistan	Austria
Burkina Faso	Cote d'Ivoire	Albania	Guatemala	Iran, Islamic Rep.	Georgia	Canada	China	Kiribati	Bangladesh	Belgium
Burundi	Ghana	Bosnia and Herzegovina	Honduras	Iraq	Kyrgyz Republic	Trinidad and Tobago	Mongolia	Lao PDR	Bhutan	Denmark
Central African Republic	Kenya	Bulgaria	Colombia	Jordan	Tajikistan	United States	Japan	Philippines	Pakistan	Finland
Comoros	Lesotho	Montenegro	Costa Rica	Lebanon	Ukraine			Timor-Leste	Maldives	Greece
Ethiopia	Mauritania	Romania	Cuba	Bahrain	Uzbekistan			Vietnam		Iceland
Gambia, The	Morocco	Serbia	Dominican Republic	Oman	Azerbaijan			Malaysia		Ireland
Guinea-Bissau	Senegal	Turkey	Mexico	Qatar	Belarus			Australia		Israel
Madagascar	Sudan	Croatia	Panama		Kazakhstan			New Zealand		Italy
Malawi	Zambia	Cyprus	Paraguay		Russian Federation			Singapore		Luxembourg
Mali	Algeria	Czech Republic	Peru		Turkmenistan					Malta
Niger	Botswana	Estonia	Argentina							Netherlands
Rwanda	Equatorial Guinea	Hungary	Chile							Norway
Somalia	South Africa	Latvia	Uruguay							Portugal
South Sudan	Tunisia	Lithuania								San Marino
Uganda	Seychelles	Poland								Spain
Zimbabwe		Slovenia								Sweden
										Switzerland
										United Kingdom

Supplementary Table S2: mHealth for accessing services [n (%)]

	Toll-free emergency						Appointment reminders						Treatment adherence					
	International	Regional	National	Intermediate	Local or peripheral level	No Response	International	Regional	National	Intermediate	Local or peripheral level	No Response	International	Regional	National	Intermediate	Local or peripheral level	No Response
Overall	3(2)	9(7)	75(60)	20(16)	18(14)	31(25)	0(0)	8(6)	39(31)	22(18)	38(30)	39(31)	1(1)	7(6)	15(12)	23(18)	35(28)	65(52)
ISN regions:																		
-Africa	0(0)	1(3)	16(48)	6(18)	4(12)	13(39)	0(0)	4(12)	12(36)	5(15)	8(24)	13(39)	1(3)	4(12)	6(18)	5(15)	9(27)	19(58)
-Eastern & Central Europe	0(0)	0(0)	9(53)	1(6)	1(6)	6(35)	0(0)	0(0)	6(35)	0(0)	6(35)	5(29)	0(0)	0(0)	2(12)	3(18)	4(24)	8(47)
-Latin America & the Caribbean	0(0)	1(7)	11(79)	4(29)	4(29)	0(0)	0(0)	1(7)	7(50)	2(14)	3(21)	3(21)	0(0)	0(0)	1(7)	4(29)	3(21)	7(50)
-Middle East	0(0)	0(0)	6(75)	0(0)	1(13)	1(13)	0(0)	0(0)	4(50)	3(38)	1(13)	1(13)	0(0)	0(0)	0(0)	1(13)	0(0)	7(88)
-NIS & Russia	0(0)	3(27)	5(45)	3(27)	3(27)	2(18)	0(0)	1(9)	1(9)	1(9)	4(36)	4(36)	0(0)	1(9)	1(9)	1(9)	4(36)	5(45)
-North America	0(0)	0(0)	4(100)	1(25)	1(25)	0(0)	0(0)	0(0)	0(0)	1(25)	2(50)	2(50)	0(0)	0(0)	0(0)	2(50)	2(50)	1(25)
-North and East Asia	0(0)	0(0)	2(50)	2(50)	1(25)	1(25)	0(0)	0(0)	0(0)	0(0)	3(75)	1(25)	0(0)	0(0)	0(0)	0(0)	1(25)	3(75)
-Oceania & South East Asia	1(10)	1(10)	8(80)	1(10)	2(20)	2(20)	0(0)	0(0)	2(20)	5(50)	3(30)	4(40)	0(0)	0(0)	1(10)	3(30)	4(40)	5(50)
-South Asia	0(0)	0(0)	1(20)	1(20)	0(0)	3(60)	0(0)	0(0)	1(20)	2(40)	2(40)	2(40)	0(0)	1(20)	2(40)	2(40)	1(20)	2(40)
-Western Europe	2(11)	3(16)	13(68)	1(5)	1(5)	3(16)	0(0)	2(11)	6(32)	3(16)	6(32)	4(21)	0(0)	1(5)	2(11)	2(11)	7(37)	8(42)
World Bank Groups:																		
-Low income	0(0)	1(5)	8(42)	3(16)	2(11)	9(47)	0(0)	2(11)	5(26)	4(21)	6(32)	7(37)	0(0)	2(11)	4(21)	4(21)	4(21)	11(58)
-Lower-middle income	1(3)	3(10)	18(60)	5(17)	6(20)	6(20)	0(0)	2(7)	12(40)	6(20)	8(27)	11(37)	1(3)	2(7)	5(17)	5(17)	9(30)	17(57)
-Upper-middle income	0(0)	0(0)	17(50)	8(24)	6(18)	10(29)	0(0)	1(3)	8(24)	5(15)	8(24)	14(41)	0(0)	2(6)	3(9)	3(9)	8(24)	20(59)
-High income	2(5)	5(12)	32(76)	4(10)	4(10)	6(14)	0(0)	3(7)	14(33)	7(17)	16(38)	7(17)	0(0)	1(2)	3(7)	11(26)	14(33)	17(40)

Figure S1: National eHealth policies / strategies across ISN regions

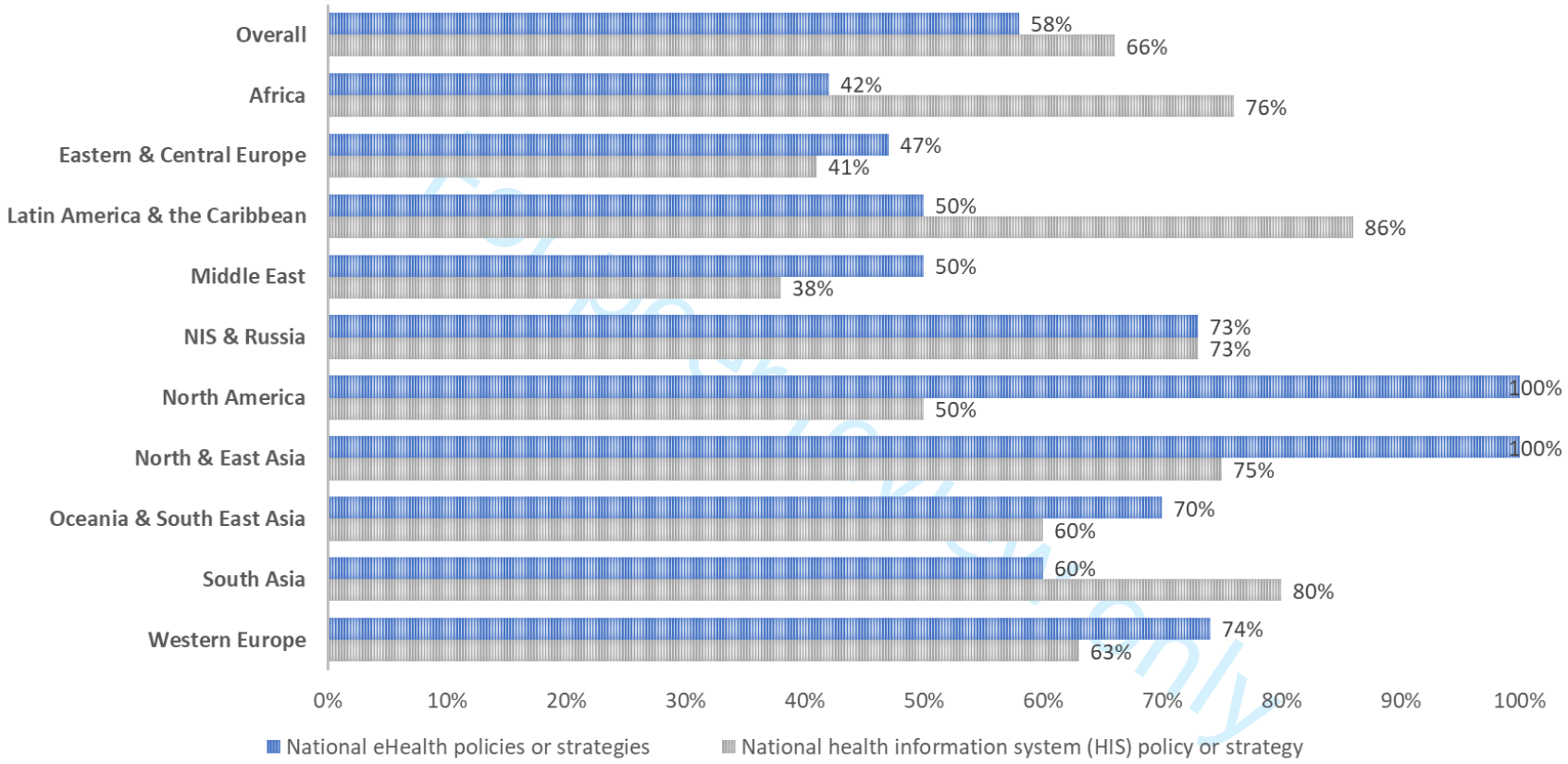


Figure S2: Funding sources for eHealth by income groups

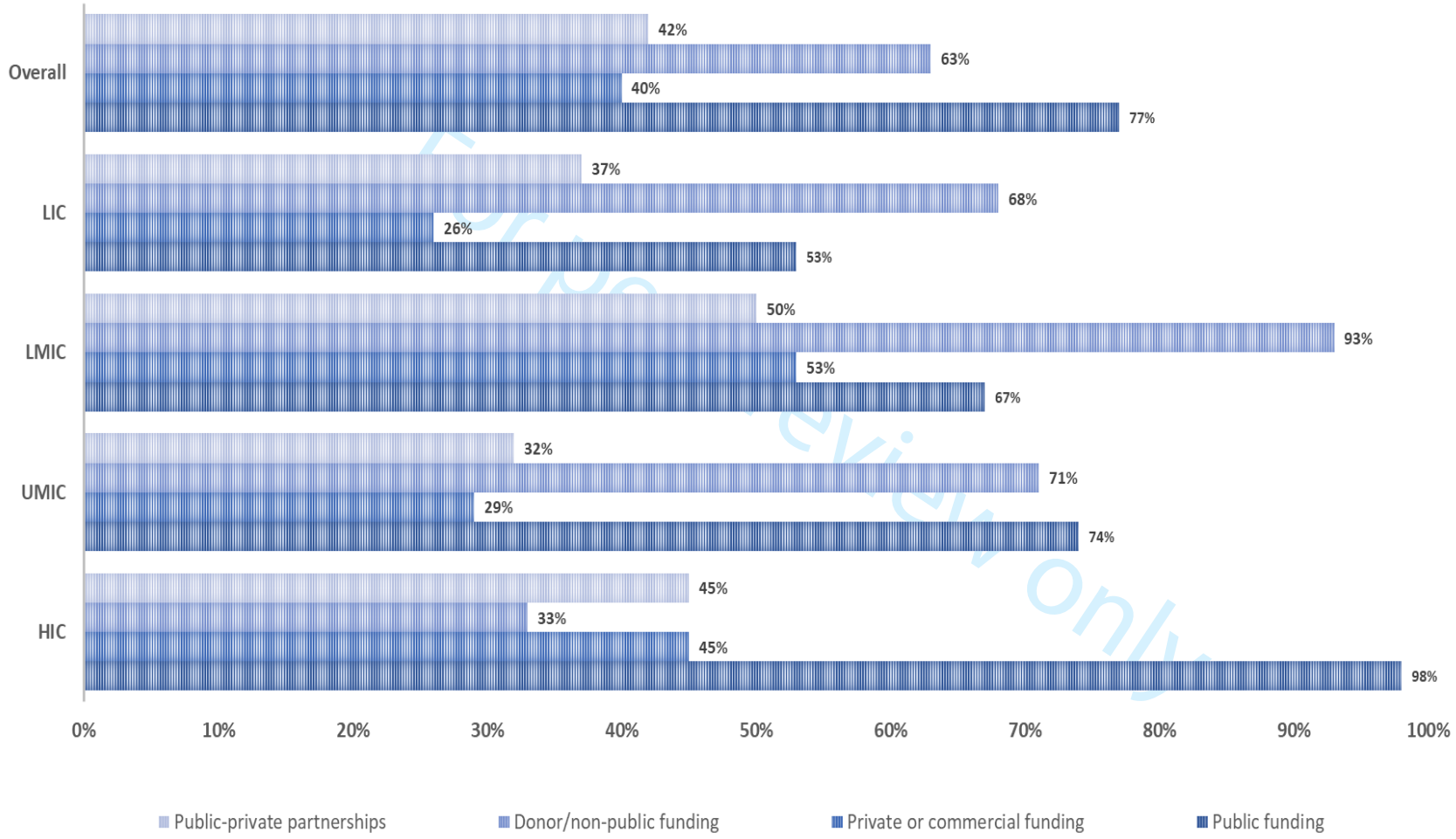


Figure S3: eHealth capacity building

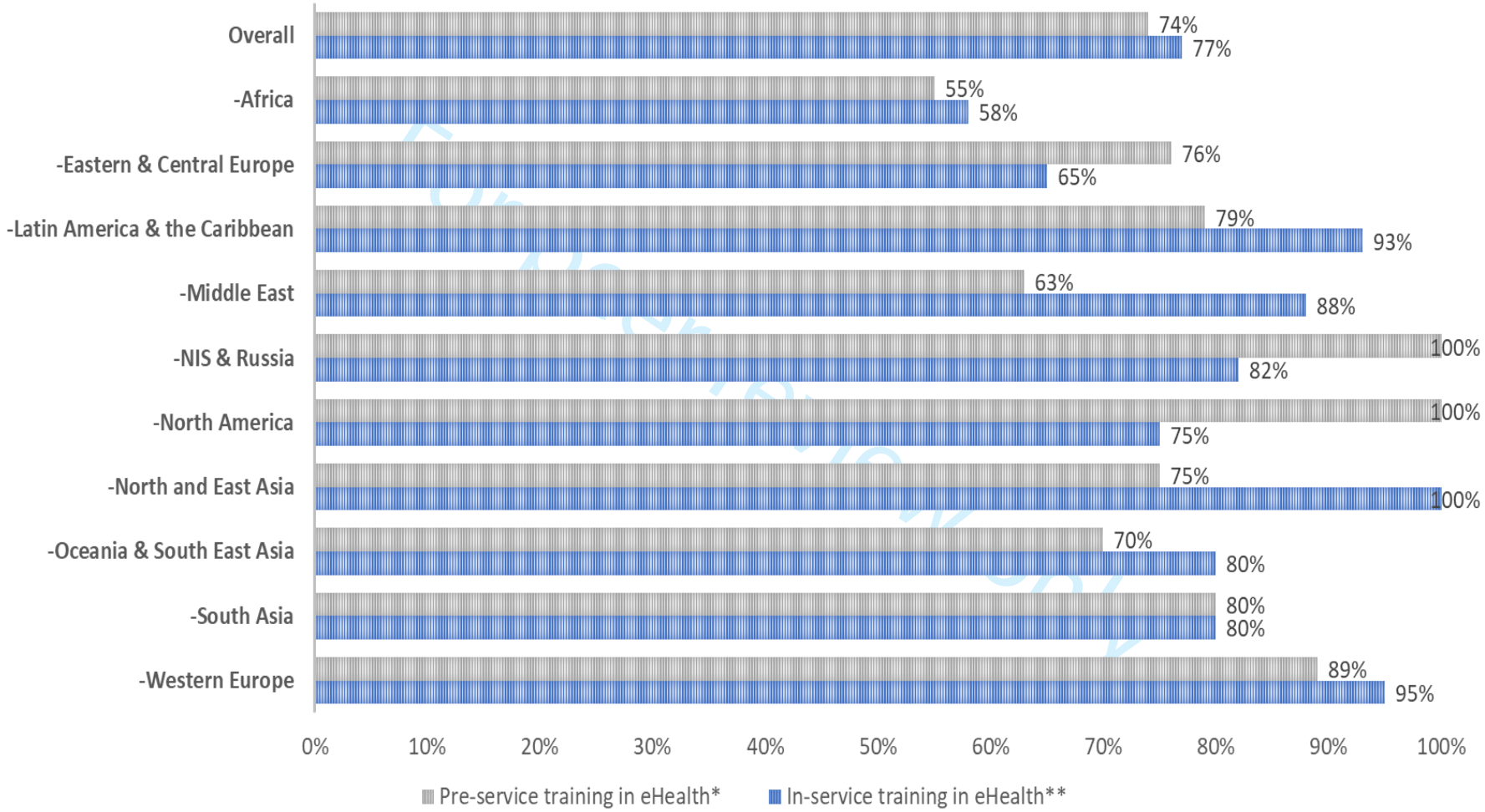


Figure S4: Use of e-learning in health sciences across ISN regions

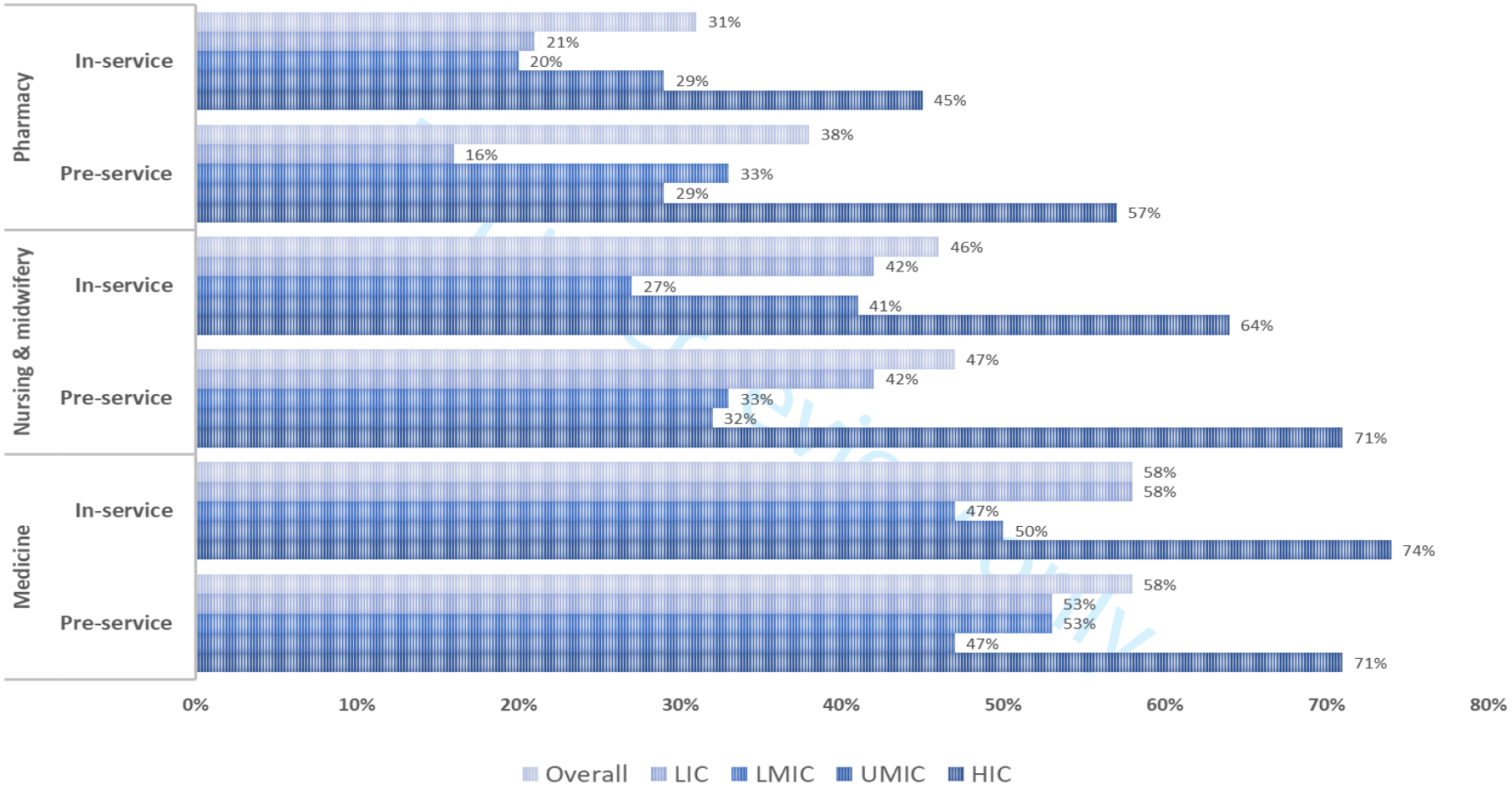


Figure S5: Health facilities with EHR in ISN regions

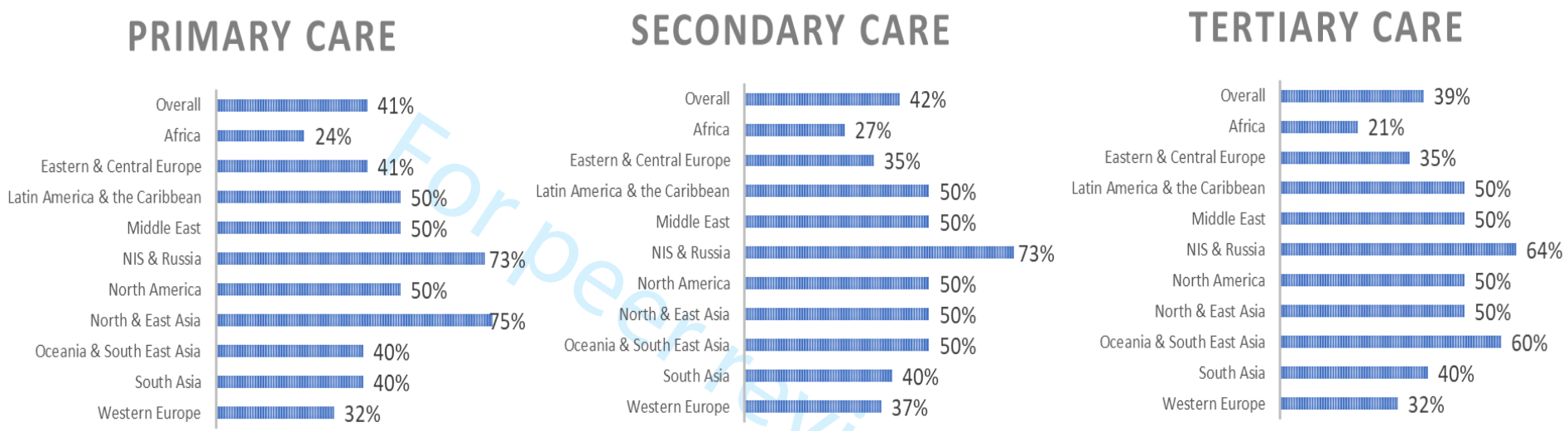


Figure S6: Availability of human resources for Health Information Systems (HIS)

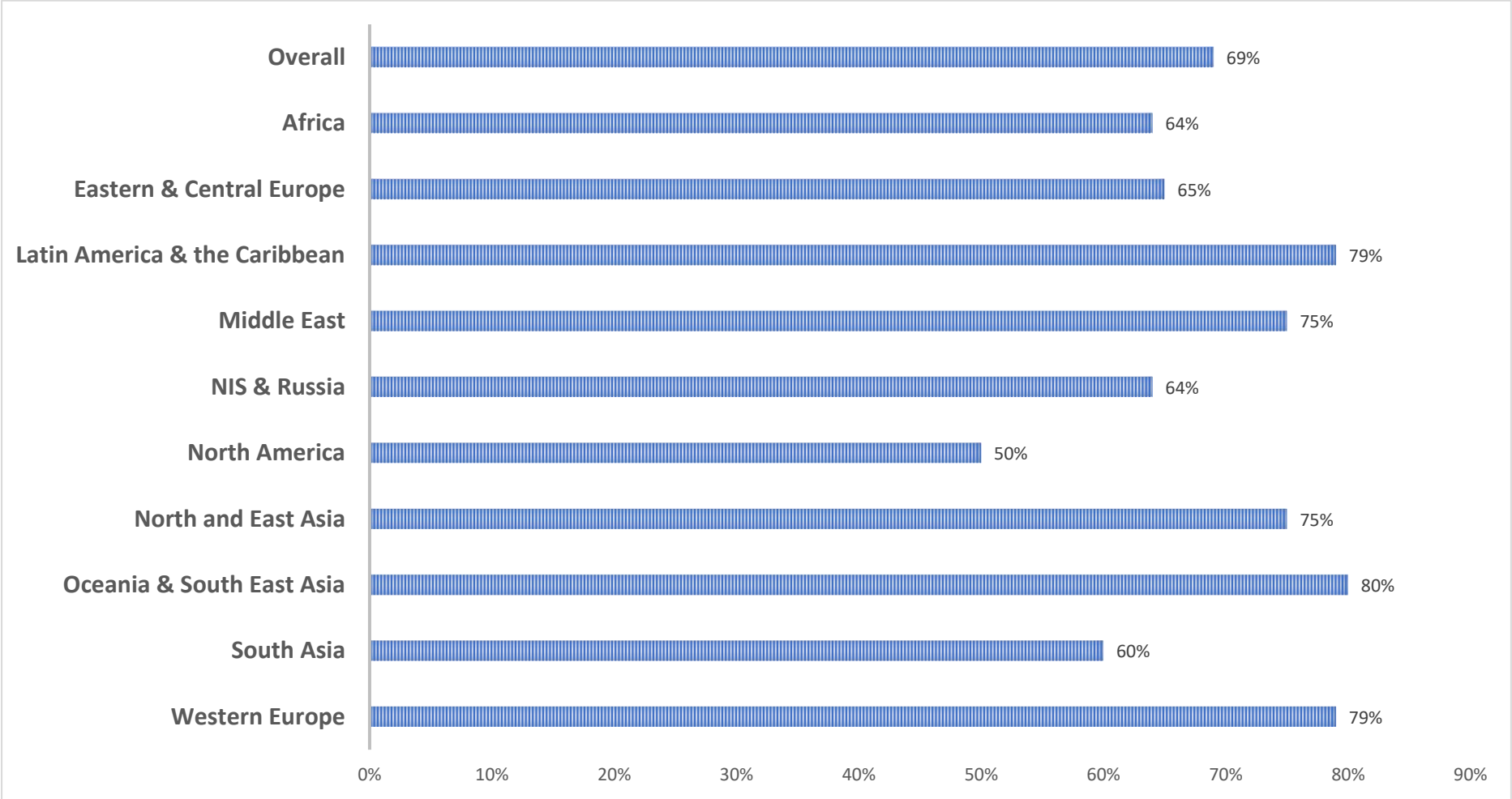


Figure S7: Legal framework for eHealth across income groups

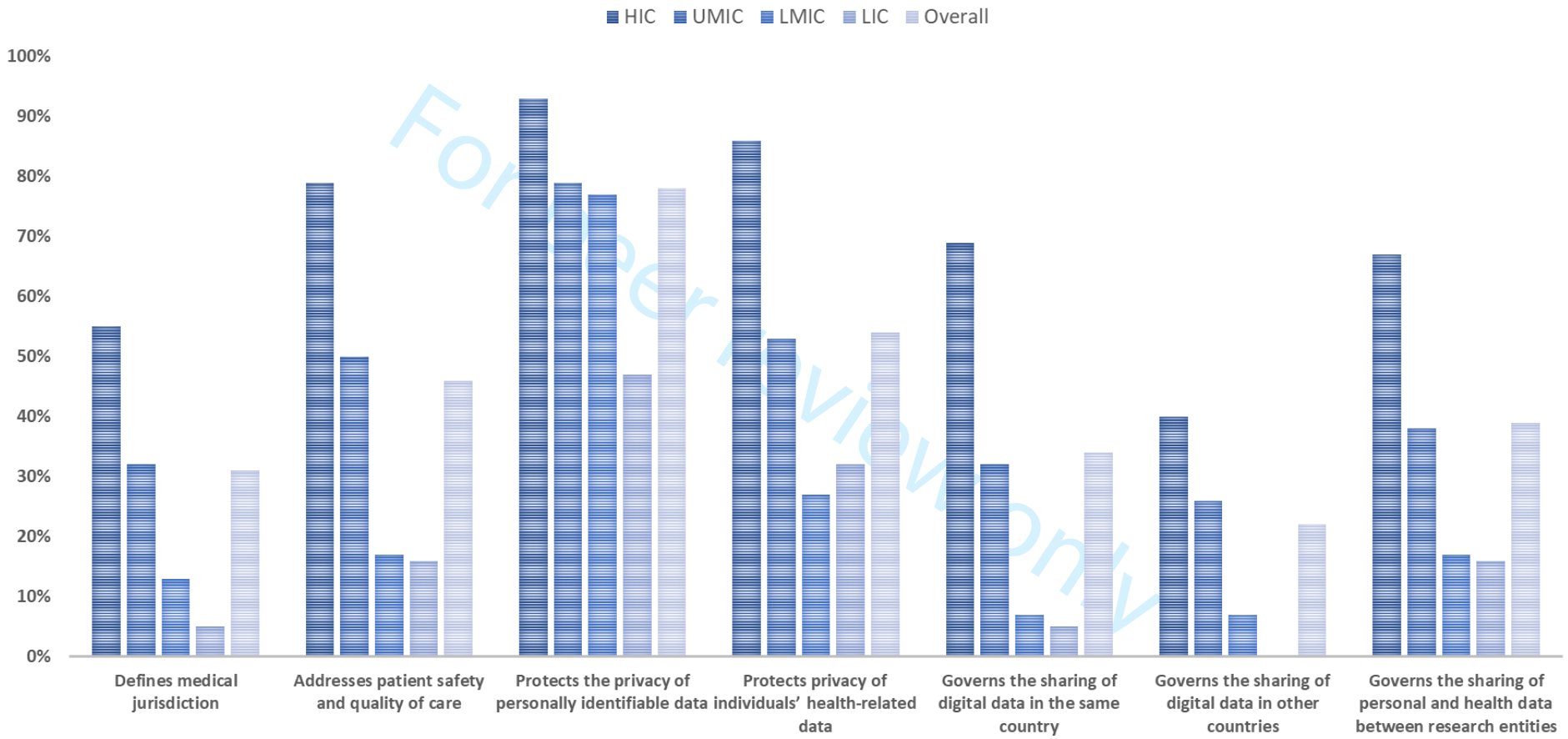


Figure S8: Health care organizations use of social media across ISN regions

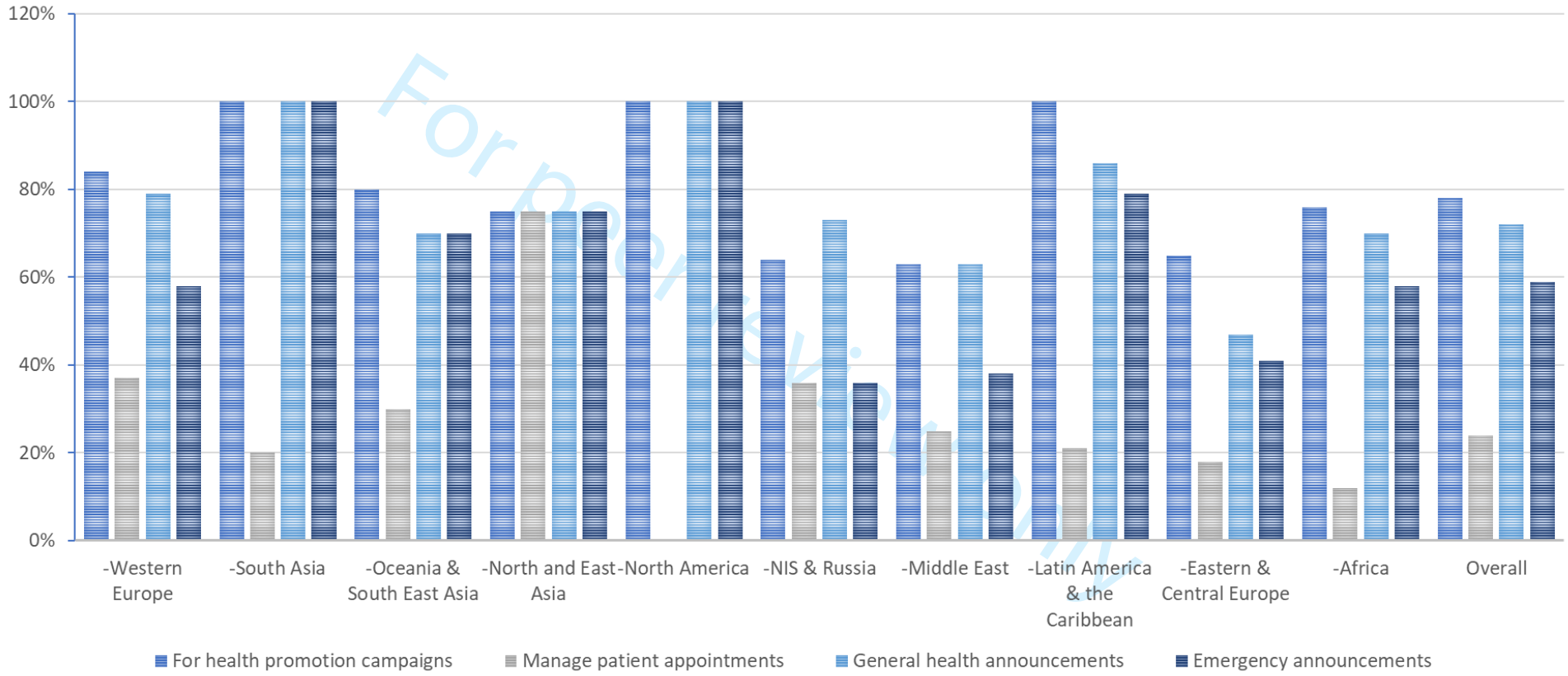
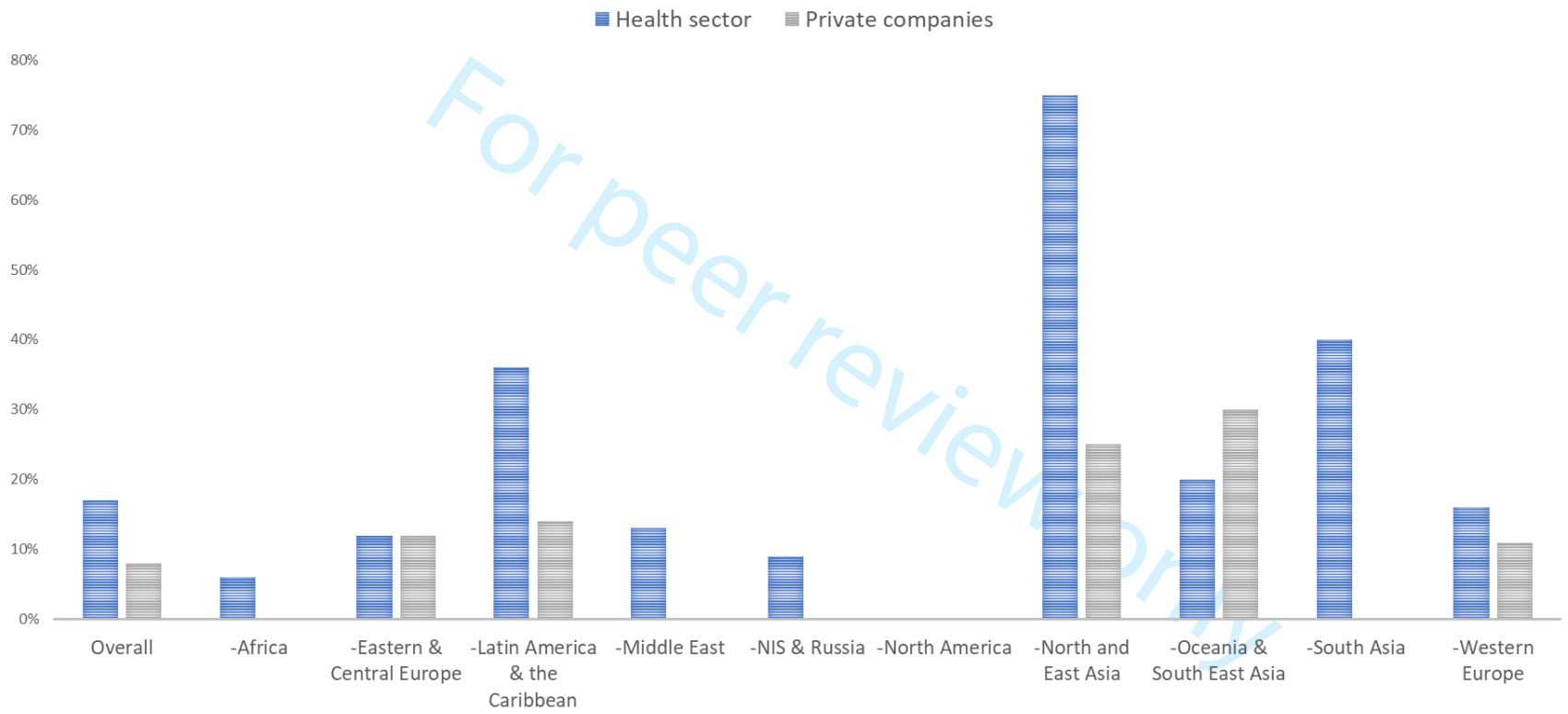


Figure S9: Policy / strategy governing the use of big data



Supplementary Appendix

Checklist for Reporting Results of Internet E-Surveys (CHERRIES)

Checklist Item	***Explanation***	***Page Number***
Describe survey design	Describe target population, sample frame. Is the sample a convenience sample? (In "open" surveys this is most likely.)	6
IRB approval	Mention whether the study has been approved by an IRB.	20
Informed consent	Describe the informed consent process. Where were the participants told the length of time of the survey, which data were stored and where and for how long, who the investigator was, and the purpose of the study?	20
Data protection	If any personal information was collected or stored, describe what mechanisms were used to protect unauthorized access.	8 (LimeSurvey)
Development and testing	State how the survey was developed, including whether the usability and technical functionality of the electronic questionnaire had been tested before fielding the questionnaire.	6-8
Open survey versus closed survey	An "open survey" is a survey open for each visitor of a site, while a closed survey is only open to a sample which the investigator knows (password-protected survey).	N/A
Contact mode	Indicate whether or not the initial contact with the potential participants was made on the Internet. (Investigators may also send out questionnaires by mail and allow for Web-based data entry.)	8
Advertising the survey	How/where was the survey announced or advertised? Some examples are offline media (newspapers), or online (mailing lists – If yes, which ones?) or banner ads (Where were these banner ads posted and what did they look like?). It is important to know the wording of the announcement as it will heavily influence who chooses to participate. Ideally the survey announcement should be published as an appendix.	8
Web/E-mail	State the type of e-survey (e.g., one posted on a Web site, or one sent out through e-mail). If it is an e-mail survey, were the responses entered manually into a database, or was there an automatic method for capturing responses?	8
Context	Describe the Web site (for mailing list/newsgroup) in which the survey was posted. What is the Web site about, who is visiting it, what are visitors normally looking for? Discuss to what degree the content of the Web site could pre-select the sample or influence the results. For example, a survey about vaccination on a anti-immunization Web site will have different results from a Web survey conducted on a government Web site	8
Mandatory/voluntary	Was it a mandatory survey to be filled in by every visitor who wanted to enter the Web site, or was it a voluntary survey?	8
Incentives	Were any incentives offered (e.g., monetary, prizes, or non-monetary incentives such as an offer to provide the survey results)?	N/A

Time/Date	In what timeframe were the data collected?	8
Randomization of items or questionnaires	To prevent biases items can be randomized or alternated.	N/A
Adaptive questioning	Use adaptive questioning (certain items, or only conditionally displayed based on responses to other items) to reduce number and complexity of the questions.	N/A
Number of Items	What was the number of questionnaire items per page? The number of items is an important factor for the completion rate.	Not reported
Number of screens (pages)	Over how many pages was the questionnaire distributed? The number of items is an important factor for the completion rate.	Not reported
Completeness check	It is technically possible to do consistency or completeness checks before the questionnaire is submitted. Was this done, and if “yes”, how (usually JAVAScript)? An alternative is to check for completeness after the questionnaire has been submitted (and highlight mandatory items). If this has been done, it should be reported. All items should provide a non-response option such as “not applicable” or “rather not say”, and selection of one response option should be enforced.	Not reported
Review step	State whether respondents were able to review and change their answers (e.g., through a Back button or a Review step which displays a summary of the responses and asks the respondents if they are correct).	Not reported
Unique site visitor	If you provide view rates or participation rates, you need to define how you determined a unique visitor. There are different techniques available, based on IP addresses or cookies or both.	Not reported
View rate (Ratio of unique survey visitors/unique site visitors)	Requires counting unique visitors to the first page of the survey, divided by the number of unique site visitors (not page views!). It is not unusual to have view rates of less than 0.1 % if the survey is voluntary.	Not reported
Participation rate (Ratio of unique visitors who agreed to participate/unique first survey page visitors)	Count the unique number of people who filled in the first survey page (or agreed to participate, for example by checking a checkbox), divided by visitors who visit the first page of the survey (or the informed consents page, if present). This can also be called “recruitment” rate.	Not reported
Completion rate (Ratio of users who finished the survey/users who	The number of people submitting the last questionnaire page, divided by the number of people who agreed to participate (or submitted the first survey page). This is only relevant if there is a separate “informed consent” page or if the survey goes over several pages. This is a measure for attrition. Note that “completion” can	10

agreed to participate)	involve leaving questionnaire items blank. This is not a measure for how completely questionnaires were filled in. (If you need a measure for this, use the word “completeness rate”.)	
Cookies used	Indicate whether cookies were used to assign a unique user identifier to each client computer. If so, mention the page on which the cookie was set and read, and how long the cookie was valid. Were duplicate entries avoided by preventing users access to the survey twice; or were duplicate database entries having the same user ID eliminated before analysis? In the latter case, which entries were kept for analysis (eg, the first entry or the most recent)?	Not reported
IP check	Indicate whether the IP address of the client computer was used to identify potential duplicate entries from the same user. If so, mention the period of time for which no two entries from the same IP address were allowed (eg, 24 hours). Were duplicate entries avoided by preventing users with the same IP address access to the survey twice; or were duplicate database entries having the same IP address within a given period of time eliminated before analysis? If the latter, which entries were kept for analysis (eg, the first entry or the most recent)?	Not reported
Log file analysis	Indicate whether other techniques to analyze the log file for identification of multiple entries were used. If so, please describe.	Not reported
Registration	In “closed” (non-open) surveys, users need to login first and it is easier to prevent duplicate entries from the same user. Describe how this was done. For example, was the survey never displayed a second time once the user had filled it in, or was the username stored together with the survey results and later eliminated? If the latter, which entries were kept for analysis (e.g., the first entry or the most recent)?	Not reported
Handling of incomplete questionnaires	Were only completed questionnaires analyzed? Were questionnaires which terminated early (where, for example, users did not go through all questionnaire pages) also analyzed?	10
Questionnaires submitted with an atypical timestamp	Some investigators may measure the time people needed to fill in a questionnaire and exclude questionnaires that were submitted too soon. Specify the timeframe that was used as a cut-off point and describe how this point was determined.	Not reported
Statistical correction	Indicate whether any methods such as weighting of items or propensity scores have been used to adjust for the non-representative sample; if so, please describe the methods.	Not reported

This checklist has been modified from Eysenbach G. Improving the quality of Web surveys: the Checklist for Reporting Results of Internet E-Surveys (CHERRIES). J Med Internet Res. 2004 Sep 29;6(3):e34 [erratum in J Med Internet Res. 2012; 14(1): e8.]. Article available at https://www.jmir.org/2004/3/e34/; erratum available https://www.jmir.org/2012/1/e8/. Copyright ©Gunther Eysenbach. Originally published in the Journal of Medical Internet Research, 29.9.2004 and 04.01.2012.

Checklist for Reporting Results of Internet E-Surveys (CHERRIES)

Checklist Item	***Explanation***	***Page Number***
Describe survey design	Describe target population, sample frame. Is the sample a convenience sample? (In "open" surveys this is most likely.)	6
IRB approval	Mention whether the study has been approved by an IRB.	20
Informed consent	Describe the informed consent process. Where were the participants told the length of time of the survey, which data were stored and where and for how long, who the investigator was, and the purpose of the study?	20
Data protection	If any personal information was collected or stored, describe what mechanisms were used to protect unauthorized access.	8 (LimeSurvey)
Development and testing	State how the survey was developed, including whether the usability and technical functionality of the electronic questionnaire had been tested before fielding the questionnaire.	6-8
Open survey versus closed survey	An "open survey" is a survey open for each visitor of a site, while a closed survey is only open to a sample which the investigator knows (password-protected survey).	N/A
Contact mode	Indicate whether or not the initial contact with the potential participants was made on the Internet. (Investigators may also send out questionnaires by mail and allow for Web-based data entry.)	8
Advertising the survey	How/where was the survey announced or advertised? Some examples are offline media (newspapers), or online (mailing lists – If yes, which ones?) or banner ads (Where were these banner ads posted and what did they look like?). It is important to know the wording of the announcement as it will heavily influence who chooses to participate. Ideally the survey announcement should be published as an appendix.	8
Web/E-mail	State the type of e-survey (e.g., one posted on a Web site, or one sent out through e-mail). If it is an e-mail survey, were the responses entered manually into a database, or was there an automatic method for capturing responses?	8
Context	Describe the Web site (for mailing list/newsgroup) in which the survey was posted. What is the Web site about, who is visiting it, what are visitors normally looking for? Discuss to what degree the content of the Web site could pre-select the sample or influence the results. For example, a survey about vaccination on a anti-immunization Web site will have different results from a Web survey conducted on a government Web site	8
Mandatory/voluntary	Was it a mandatory survey to be filled in by every visitor who wanted to enter the Web site, or was it a voluntary survey?	8
Incentives	Were any incentives offered (e.g., monetary, prizes, or non-monetary incentives such as an offer to provide the survey results)?	N/A

Time/Date	In what timeframe were the data collected?	8
Randomization of items or questionnaires	To prevent biases items can be randomized or alternated.	N/A
Adaptive questioning	Use adaptive questioning (certain items, or only conditionally displayed based on responses to other items) to reduce number and complexity of the questions.	N/A
Number of Items	What was the number of questionnaire items per page? The number of items is an important factor for the completion rate.	Not reported
Number of screens (pages)	Over how many pages was the questionnaire distributed? The number of items is an important factor for the completion rate.	Not reported
Completeness check	It is technically possible to do consistency or completeness checks before the questionnaire is submitted. Was this done, and if "yes", how (usually JAVAScript)? An alternative is to check for completeness after the questionnaire has been submitted (and highlight mandatory items). If this has been done, it should be reported. All items should provide a non-response option such as "not applicable" or "rather not say", and selection of one response option should be enforced.	Not reported
Review step	State whether respondents were able to review and change their answers (e.g., through a Back button or a Review step which displays a summary of the responses and asks the respondents if they are correct).	Not reported
Unique site visitor	If you provide view rates or participation rates, you need to define how you determined a unique visitor. There are different techniques available, based on IP addresses or cookies or both.	Not reported
View rate (Ratio of unique survey visitors/unique site visitors)	Requires counting unique visitors to the first page of the survey, divided by the number of unique site visitors (not page views!). It is not unusual to have view rates of less than 0.1 % if the survey is voluntary.	Not reported
Participation rate (Ratio of unique visitors who agreed to participate/unique first survey page visitors)	Count the unique number of people who filled in the first survey page (or agreed to participate, for example by checking a checkbox), divided by visitors who visit the first page of the survey (or the informed consents page, if present). This can also be called "recruitment" rate.	Not reported
Completion rate (Ratio of users who finished the survey/users who	The number of people submitting the last questionnaire page, divided by the number of people who agreed to participate (or submitted the first survey page). This is only relevant if there is a separate "informed consent" page or if the survey goes over several pages. This is a measure for attrition. Note that	10

agreed to participate)	"completion" can involve leaving questionnaire items blank. This is not a measure for how completely questionnaires were filled in. (If you need a measure for this, use the word "completeness rate".)	
Cookies used	Indicate whether cookies were used to assign a unique user identifier to each client computer. If so, mention the page on which the cookie was set and read, and how long the cookie was valid. Were duplicate entries avoided by preventing users access to the survey twice; or were duplicate database entries having the same user ID eliminated before analysis? In the latter case, which entries were kept for analysis (eg, the first entry or the most recent)?	Not reported
IP check	Indicate whether the IP address of the client computer was used to identify potential duplicate entries from the same user. If so, mention the period of time for which no two entries from the same IP address were allowed (eg, 24 hours). Were duplicate entries avoided by preventing users with the same IP address access to the survey twice; or were duplicate database entries having the same IP address within a given period of time eliminated before analysis? If the latter, which entries were kept for analysis (eg, the first entry or the most recent)?	Not reported
Log file analysis	Indicate whether other techniques to analyze the log file for identification of multiple entries were used. If so, please describe.	Not reported
Registration	In "closed" (non-open) surveys, users need to login first and it is easier to prevent duplicate entries from the same user. Describe how this was done. For example, was the survey never displayed a second time once the user had filled it in, or was the username stored together with the survey results and later eliminated? If the latter, which entries were kept for analysis (e.g., the first entry or the most recent)?	Not reported
Handling of incomplete questionnaires	Were only completed questionnaires analyzed? Were questionnaires which terminated early (where, for example, users did not go through all questionnaire pages) also analyzed?	10
Questionnaires submitted with an atypical timestamp	Some investigators may measure the time people needed to fill in a questionnaire and exclude questionnaires that were submitted too soon. Specify the timeframe that was used as a cut-off point and describe how this point was determined.	Not reported
Statistical correction	Indicate whether any methods such as weighting of items or propensity scores have been used to adjust for the non-representative sample; if so, please describe the methods.	Not reported

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