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Article

A Rapid Review of the Use of Appropriate Technology in Global Health

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The need for appropriate technology in global health has expanded dramatically as the gap between industrialized and developing countries continues to expand. However, there is no collective knowledge of appropriate technology in global health. Thus, this study intends to provide light on the latest developments in the field of appropriate technology in global health and to speculate on future directions. A rapid review, or simplified technique, was used to systematically identify and summarize emerging papers. The search technique used the keywords "global health" and "appropriate technology." The total number of papers collected from PubMed and Scopus was 427, and 19 articles were thoroughly reviewed for the result section following the research. The study's conclusions included the following: 1) an assessment of appropriate technology adopted in developing countries; and 2) strategies for implementing appropriate technologies in global health. Additionally, we drew lessons and identified problems to serve as a useful guide for future research and development in appropriate technology. This review uncovered a small but valuable level of information about acceptable technology in global health.

KEYWORDS: global health, appropriate technology, rapid review, developing countries

Introduction

Appropriate technology is defined as any object, idea, process, or practice that fulfills human needs under consideration of the community's political, cultural, environmental, and economic conditions. Economist Dr. Ernest Friedrich Schumacher, who first coined the term "appropriate technology," argued that appropriate technology must be small scaled, locally controlled, inexpensive, ecologically sound, energy efficient, labor-intensive, and compatible with human needs (Schumacher n.d.). Such features of appropriate technology make appropriate technology a good foundational tool for less developed countries to fulfill the basic needs of their people who have been largely left out from the modern industrial process.

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The need of appropriate technology in global health has significantly increased following the ever-growing gap in economic development between developed and developing countries. The economic gap has been a major limiting factor in transferring developed countries' health related services and technology to developing countries. As a result, appropriate technology has played an effective mechanism that transformed modern technology into what can be most ideally accepted by those who use it.

The WHO Basic Radiology System (BRS) in 1975 is an example of appropriate technology in global health. BRS is a "simplified version of a standard radiographic unit" that can perform routine radiographic examinations in regions deprived of radio diagnostic service for economic and geographic reasons (World Health Organization 1994). The WHO BRS demonstrated high quality images and administrative advantages including safety, energy efficiency, and ease of use. By 1991 the WHO BRS was known to report the highest number of

radiographs awarded and met the common needs of the majority in cases such as fracture, pregnancy, chest diseases, parasites, and abdominal pain (ibid).

Current uses of appropriate technology in global health are countless. Appropriate technology is used in laboratory medicine technology, allowing rapid and easy-to-access diagnostic tests to infectious diseases such as tuberculosis, HIV, hepatitis B and hepatitis C. Its use is also found in gene technology, starting from early detection and prevention of infectious disease and hereditary diseases to application in food production. It also enhanced the delivery system of pharmaceuticals and is widely used in environmental health to clean wastewater and develop safe housing designs.

However, appropriate technology still lays concerns before it gaps knowledge and application. Common limitations of application of appropriate technology include lack of access to databases or other sources of information, lack of funding, lack of commitment and political support, weak national health care system, poorly equipped hospitals, and lack of national expertise. As such, it is critical for global and national health institutions to collaborate with local organizations and donor agencies to ensure that they accurately review limitations of existing systems and develop more rational mechanisms that are effective according to the community's needs and priorities. By categorizing and summarizing the evidence, this rapid review aimed to provide a present status of existing research of appropriate technology in global health.

Method

Rapid review is a form of systematic review in which current studies are carefully examined to see if they match the researcher's point of view or a specific research issue. In this regard, rapid review is useful for knowledge synthesis. We conducted a rapid review based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) checklist in order to examine the current status and application cases of health-related appropriate technologies globally and to present the factors that influence the introduction of such appropriate technologies.

1. Eligibility criteria

Appropriate Technology is described as "any object, idea, process, or practice that fulfills human needs while taking into account the community's political, cultural, environmental, and economic conditions," as previously said. The medical system or systemic improvement can also be offered as a form of health-related appropriate technology. In light of the current pandemic crisis and the broad availability of mobile devices, it presents the possibility of expanding appropriate technology offered in a non-face-to-face public approach as a means of medical system development. This paper developed the following screening criteria based on this viewpoint on appropriate technology. Records are widely collected through PubMed and Scopus using the phrases "global health" AND "appropriate technology" and verified for eligibility through the following steps:

1. A record is excluded and categorized as 'Content beyond scope' if it merely provides a simple technical introduction, animal-related intervention, or consequence that is assessed to be unrelated to health.

2. If a record isn't regarded an original article, such as a review or commentary, we opted to remove it and label it as "Not original study."

Papers that presented criteria in the process of introducing appropriate technology were also included as a result of researcher discussion.

2. Study selection

The following process was used to choose the studies. A total of 427 papers were uploaded in the Rayyan system (http://rayyan.qcri.org), a free web-based research tool for systematic review. Then it was uploaded to the Mendeley program for review. 194 papers were deleted from the screening process because they were duplicates. The first round of screening was done using abstract analysis, and 168 items were eliminated. A secondary screening was carried out for more thorough verification. 23 records were identified as having content that was outside the scope of the project and were removed. A total of 23 entries were categorized as a non-original study, displaying Review or Commentary characteristics. In total, 42 papers were rejected based on the aforementioned criteria. The remaining 19 records were chosen as research articles, and mutual verification was carried out through talks among scholars.

Results

1. Characteristics of the selected studies

The features of the 19 studies considered in the review are

Table 1. Characteristics of included studies (n=19)

First Author, Year	Research study design	Research location	Research sample	Research objective	Outcome measures
Morse *et al.*, 2020	Transdisciplinary research and formative research	Malawi	1) shared dialogue workshops (n = 5), 2) sociospatial survey (n = 777), 3) water point mapping and testing (n = 46), and 4) risks, attitudes, norms, abilities, and self-regulation (RANAS) survey (n = 100)	Aims to address the needs of the target population; Introduced an HWTS that can be successfully taken up and rolled out, the present study took into consideration the opinions of the householders, the socioeconomics of the households as the context of the design, opportunities for local and cost-effective manufacture, and the need for complementary and appropriate educational tools; Encompassed facets of technology, social context, and psychosocial factors using the De Buck *et al.* (2018) theory of change as a framework.	1. Demographics 2. Household water management and gender-related issues 3. Water-related social capital and conflicts 4. Water point mapping and water quality tests 5. Behavioral factors influencing water treatment6. Community codesign 7. Moving toward trial
Liang *et al.*, 2018	a cross-sectional study	Uganda	28 users (6 doctors, 3 clinical officers, 6 nurses, 4 other health professionals, 6 administrative staff, and 3 support staff)	Describes the key opportunities and challenges in EHR development in sub-Saharan Africa and to summarize the development and implementation of a "Made-for-Africa" EHR, Stre@mline, and how it has led to improved care for over 60,000 vulnerable patients in a rural region of Southwestern Uganda.	1. system usability 2. performance
Jeronimo *et al.*, 2014	clinical trial	1) India 2) Nicaragua 3) Uganda.	16,951 women - Rural Uttar Pradesh: 4,658 - Hyderabad: 3,562 - Nicaragua: 4,645 - Uganda: 3,146	Evaluates the feasibility and performance of careHPV, a novel hu- man papillomavirus (HPV) DNA test, when used for screening women for cervical cancer in low-resource settings	4 screening tests: 1) a self-collected vaginal sample for careHPV testing 2) a pelvic examination using a speculum during which additional cervical samples were taken for careHPV and conventional Papanicolaou test 3) careHPV specimen for both vaginal and cervical samples 4) Visual inspection with acetic acid L5
Sesan, 2012	qualitative study	Kenya	24 non-elite and elite	Highlights the implications of the findings presented here for energy poverty alleviation and improved stove development policy	1. Description and cost of smoke alleviation interventions promoted by Practical Action in selected research site 2. Socio-cultural realities influence household priorities 3. Economic realities determine household priorities 4. The United States Environmental Protection Agency (USEPA) smoke alleviation project: targets, strategies, outcomes
Parham *et al.*, 2010	case study	Zambia	n/a	Present a system operated by nonphysician health providers that used widely available and affordable communication technology to create locally adaptable and sustainable public sector cervical cancer prevention program in Zambia	1. Trained nurses to perform visual inspection with acetic acid aided by digital cervicography using predefined criteria 2. Materials required for digital cervicography 3. Reviewed electronic digital images 4. Same-visit cryotherapy or referral for further evaluation by a gynecologist

Table 1. Continued

First Author, Year	Research study design	Research location	Research sample	Research objective	Outcome measures
Dunmade *et al.*, 2002	narrative study	Nigeria	n/a	Identifies indicators that will help assess the sustainability of these foreign technologies—indicators that will inform and guide all stakeholders as they make decisions regarding the acceptability of all such technology in the nation	1. Previous considerations of sustainability 2. Primary indicators of foreign technology sustainability 3. Secondary indicators of foreign technology sustainability
Labbé *et al.*, 2001	clinical trial study	The Lao People's Democratic Republic	194 blood sample of individuals with fever or a history of fever	Evaluates the performance of one simple, rapid and inexpensive diagnostic assay when used by trained local healthcare providers in a rural field setting in Laos	1. sensitivity 2. specificity
Mulokozi *et al.*, 2001	clinical trial study	Tanzania	Preintervention: 250 (intervention) 150 (control) Postintervention: 239 (intervention) 126 (control) (4% and 16% loss to follow-up)	Explores three ways to increase the dryers' nutritional impact. 1) designing models that responded to women's needs, more dryers might be constructed, increasing the production of dried foods. 2) developing an education strategy that ensured that all community members received the same basic information, families might adopt the dryers and feed the nutritionally rich dried food products to their 12- to 71-month-old children. 3) providing women with additional nutritional information and skill training might make them feel more empowered to access the resources they needed to adopt the improved technology.	1. Women's knowledge of solar drying 2. Percentage of Production of dried foods 3. The amount of β-carotene in vegetables blanched 4. Helen Keller International (HKI) food-frequency method
Khodadadeh *et al.*, 2001	randomized controlled trial	Iran	45 in the prototype (n = 25) in the electrical incubator (n = 20)	The main aim of the present study was to assess the technical feasibility, efficiency and safety of the prototype by comparing it with an air-heated electrical incubator in routine use in the hospitals.	1. rectal and abdominal skin temperature, heart rate, oxygen 2. saturation and respiratory rate 3. The temperature, oxygen and humidity level of the canopy and the room temperature
Parashari *et al.*, 2000	clinical trial study	India	403 women attending a maternal and child health care clinic who had abnormal vaginal discharge and related symptoms	To improve the sensitivity of visual inspection and reduce the numbers of non-specific results as much as possible	comparison with those obtained using colposcopy and/or histology
Nelson *et al.*, 1999	clinical trial study	Indonesian island of Lombok	385 soloshat, 433 disposables	Investigates the appropriateness of SoloShot in the Indonesian campaign, compared to a standard disposable syringe, in terms of vaccine wastage, dose accuracy, and user acceptability	1. accuracy 2. dose efficiency
Leggat *et al.*, 1997	case study	n/a	n/a	Examines the need for and the approach of the WHO in developing and introducing the BRS, and the developments after the introduction of the WHO-BRS, which target ultrasound equipment.	1. the need for diagnostic imaging equipment 2. appropriate technology for better health 3. the WHO basic radiological system 4. the next step: ultrasound

Table 1. Continued

First Author, Year	Research study design	Research location	Research sample	Research objective	Outcome measures
Free, 1992	narrative study	n/a	n/a	Overviews several strategies and mechanisms that have been employed by the Program for Appropriate Technology in Health over the past decade to address the unmet needs for health technologies in the developing world	1. public/private partnerships in the development of priority technologies for health 2. an overview of mechanisms by which the public sector can address health technology needs 3. collaboration to develop a consensus of need and a strategy for development 4. Identification of a technology to meet the need 5. Identification of manufacturing partners 5. Incentives for commercial involvement in social technologies 6. protecting the public sector's interests 7. The role of bridging organizations in public/private partnerships
Ong, 1991	narrative study	n/a	n/a	Discusses some of the problems faced by developing countries in technology transfer	1. Components of work factors in human-machine relationships 2. the role of the operator 3. Matching technology with users 4. Workplace characteristics and working environment 5. Human resources and economic factors
Ritenbaugh *et al.*, 1989	clinical trial	Egypt	343 infants in developing countries	Determines whether a system could be developed which would provide adequate epidemiologic data on pregnancy and birth outcome to serve as part of a monitoring system; detail the methods used to address the above questions and to partially test the proposed system	1. weight of babies 2. sensitivity 3. specificity
Nabarro *et al.*, 1988	clinical trial	Developing countries	children in developing countries	Re-examines the importance of widespread growth monitoring as a part of child care in developing countries	1. assessment of health and growth of child
Monk *et al.*, 1984	narrative study	Bangladesh	Halda river water quality	Designs a low-technology water treatment plant for developing nations to fit local conditions	1. Beneficial and cost-effective results for the client in a developing nation 2. satisfaction of the design engineer
Sanborn *et al.*, 1984	clinical trial	Mali and Upper Volta	50 specimens	Describes preliminary field evaluations of a portable coagglutination test kit for the rapid, specific bedside diagnosis of meningitis patients	Comparison of coagglutination test results on CSF specimens for the diagnosis of meningitis which were obtained by African medical attendants and verified by an established microbiology laboratory
Feachem, 1980	narrative study	n/a	n/a	Introduces a case appropriate technology and community participation and explores negative view	1. concept of appropriate technology 2. selecting appropriate technology 3. simplicity and maintenance 4. a fashionable approach 5. issues in community participation 6. aims of community participation

summarized in Table 1. The research location is one of the elements extracted. The research was conducted in low- and middle-income countries on the African and Asian continents. Nine research (9/19, 47.3%) have been completed in the African region (Dunmade, 2002; Liang *et al.*, 2018; Morse *et al.*, 2020; Mulokozi *et al.*, 2001; Parham *et al.*, 2010; Ritenbaugh *et al.*, 1989; Sanborn and Toure, 1984; Sesan, 2012); and five studies (5/19, 26.3%) have been completed in the Asian region (Khodadadeh *et al.*, 2001; Labbé *et al.*, 2001; Monk, Hall, and Hussain, 1984; Nelson, Sutanto, and Suradana, 1999; Parashari *et al.*, 2000). Another feature that has been retrieved is the research design. This review categorized the selected papers on appropriate technology and global health according to their research designs. The research designs used in selected studies include narrative research (6/19, 31.6%) (Dunmade, 2002; Feachem, 1980; Free, 1992; Monk, Hall, and Hussain, 1984; Nabarro and Chinnock, 1988; Ong, 1991), clinical trial research (6/19, 31.6%) (Jeronimo *et al.*, 2014; Labbé *et al.*, 2001; Mulokozi *et al.*, 2001; Nelson, Sutanto, and Suradana, 1999; Parashari *et al.*, 2000; Ritenbaugh *et al.*, 1989; Sanborn and Toure, 1984), case studies (2/19, 10.5%) (Parham *et al.*, 2010), randomized control trial research (1/19, 5.3%) (Khodadadeh *et al.*, 2001), qualitative research (1/19, 5.3%) (Sesan, 2012), cross-sectional research (1/19, 5.3%) (Liang *et al.*, 2018), and transdisciplinary research (1/19, 5.3%) (Morse *et al.*, 2020). Additionally, the selected studies' objectives and outcomes were obtained. The studies that were chosen to highlight the following outcomes: performance, usability, and needs. Ten studies illustrated the performance of appropriate technology launched there in research (10/19, 52.6) (Jeronimo *et al.*, 2014; Khodadadeh *et al.*, 2001; Labbé *et al.*, 2001; Liang *et al.*, 2018; Nabarro and Chinnock, 1988; Nelson, Sutanto, and Suradana, 1999; Parashari *et al.*, 2000; Parham *et al.*, 2010; Ritenbaugh *et al.*, 1989; Sanborn and Toure, 1984; Sesan, 2012), four studies included usability as a research objective and measure (4/19, 21.1%) (Dunmade, 2002; Monk, Hall, and Hussain, 1984; Morse *et al.*, 2020; Ong, 1991), two studies joint performance and usability (2/19, 10.5%) (Liang *et al.*, 2018; Mulokozi *et al.*, 2001), and two studies indicated the need for appropriate technology (2/19, 10.5%) (Free, 1992; Leggat, 1997).

2. Evaluation of appropriate technologies implemented in developing countries

Fifteen studies examined appropriate technologies in developing countries, and we analyzed the evaluation results to identify the strengths, limitations, and recommendations for appropriate technology use. Table 2 summarizes the assessment for each study. These findings were mainly positive in their evaluation of appropriate technology use in low-resource settings. The majority of studies evaluated appropriate technologies as easy to use (Khodadadeh *et al.*, 2001; Labbé *et al.*, 2001; Mulokozi *et al.*, 2001; Nelson, Sutanto, and Suradana, 1999). Numerous studies have demonstrated the cost-effectiveness of appropriate technologies (Leggat, 1997; Parashari *et al.*, 2000; Parham *et al.*, 2010). According to certain research, appropriate technology can help decrease health risks by supplying drinkable water and reducing smoke generated during cooking (Morse *et al.*, 2020; Sesan, 2012). Furthermore, studies have indicated a beneficial influence on women's productivity and efficiency (Mulokozi *et al.*, 2001), improvements in patient assessment (Nabarro and Chinnock, 1988; Ritenbaugh *et al.*, 1989), speed of use (Sanborn and Toure, 1984), and maximizing of local labor and resources (Monk, Hall, and Hussain, 1984).

This rapid review also explored limitations. Some studies mentioned a deficiency of necessary functions (Khodadadeh *et al.*, 2001; Parham *et al.*, 2010). Several studies also cited disputes amongst community residents, such as artisans demanding high fees for their services (Mulokozi *et al.*, 2001), and competition between traditional birth attendants and nurses over the use of appropriate technology (Ritenbaugh *et al.*, 1989). Certain research indicated low community participation in implementing appropriate technologies as their limitation (Morse *et al.*, 2020; Nabarro and Chinnock, 1988). As per with one study, their constraint is the inability to discard huge disposables of appropriate technology (Nelson, Sutanto, and Suradana, 1999), while another study discovered a lack of data portability between hospitals (Liang *et al.*, 2018). Furthermore, one study noted that appropriate technology was difficult to learn at first use (Sesan, 2012).

Notable recommendations include the use of community leadership (Morse *et al.*, 2020), user training (Jeronimo *et al.*, 2014; Liang *et al.*, 2018), sequential piloting of appropriate technology (Liang *et al.*, 2018), an evaluation method at each stage of implementation (Parham *et al.*, 2010; Sesan, 2012), and additional appropriate technology that would enhance the integration of existing technology (Leggat, 1997; Parashari *et al.*, 2000).

Table 2. Characteristics of Appropriate Technologies in the Selected Studies (n=15)

Category	Appropriate technology	Product details	User	Evaluation	Recommendations
technology	Solar disinfection (SODIS) system Developed by Helvetas Swiss Intercooperation and the ETH-Water Research Institute Eawag Morse *et al.*, 2020	water treatment at the household level	Community residents	Strength 1. provide drinkable water which fits to the WHO water standards Limitations 1. gender issue 2. low community participation	1. the use of community leadership (traditional, religious, government workers, etc.) and volunteers as change agents who will be in place for the long term and can integrate the promotion of the SODIS system with other water, sanitation, and hygiene interventions 2. must be cognizant of both male and female perceptions and financial priorities
health technology-digital	Stre@mline platform (EHR system) Developed by Ugandan software developers (istreams) and a team of physicians from the Kisiizi Hospital (private not-for-profit hospital in Southwestern Uganda) Liang *et al.*, 2018	providing an ideal context for the development of a system ideal for rural and remote health facilities in sub-Saharan Africa.	healthcare workers	Strengths 1. well-designed, sustainable and scalable technological solutions for local settings 2. effective local support for maintenance and further development through an intimate understanding of local needs 3. economically sustainable, with less external donor funding needed 4. local pride can be an important contributor to the adoption of any technology and well leveraged in the development and application of Stre@mline 5. strong leadership from clinician-administrators Limitations 1. lack of data portability between different hospitals 2. cost prohibitive for small public hospitals and clinics within Uganda and other African countries	1. ensure and mandate computer workshops for all hospital employees 2. organize piloting the EHR sequentially, one department at a time, until it was scaled across each department
health technology	*care*HPV Test Kit Developed by QIAGEN, Gaithersburg, MD Jeronimo *et al.*, 2014	a simplified, robust, and affordable HPV test that could be used in low-resource settings under a wider range of ambient conditions	women	Strengths 1. can be run in any room because it does not need running water or air conditioning 2. the process is simple and can be completed by people with limited laboratory training 3. does not require pelvic evaluation Limitations 1. may overestimate the clinical sensitivity of the tests evaluated and the results	1. the performance of local expert should be adequate
technology	Improved cooking stove (various prototype exists) Sesan, T., 2012	to burn biomass more efficiently and hence uses less fuel, or emits less smoke, than traditional cooking devices	Community residents	Strengths mitigation of smoke-related health problems, reduction of human and financial capital spent in obtaining biomass fuels, reduced pressure on forest resources; and reduced greenhouse gas emissions Limitations many poor households find it difficult to pay for these 'low-cost' interventions in the first instance/ some cookers (like the solar cooker) requires young women because its difficult to learn how to use it	more measured steps which respond to the socio-economic realities of poor households are likely to engender more appropriate solutions

Table 2. Continued

Category	Appropriate technology	Product details	User	Evaluation	Recommendations
health technology-digital	electronic cervical cancer control (eC3) developed by Center for Infectious Disease Research in Zambia Parham *et al.*, 2010	a system operated by nonphysician health providers that used widely available and affordable communication technology to create locally adaptable and sustainable public sector cervical cancer prevention program in Zambia	nurses	Strengths a low- cost and locally appropriate platform for the integration of future HPV-based cervical cancer screening protocols Limitations 1. photographs are two-dimensional 2. the ability of consultants to make appropriate decisions is limited 3. if cameras fail, need to be sent outside the country for repair 4. digital cervicography is only a screening test and, to be effective	1. must be incorporated within a system where its results can be monitored, evaluated, assessed by experts, and linked with appropriate treatment when necessary
health technology	dipstick assay developed by the Program for Appropriate Technology in Health (PATH) Labbé *et al.*, 2001	Detect true P. falciparum infections reliably	health care worker	Strengths 1. the field health care workers were quickly taught how to use and to interpret the results of the PATH assay 2. rapid Limitations 1. specificities may have increased if PCR had been used as the reference standard	n/a
technology	solar dryers developed by Tanzania Food and Nutrition Centre (TFNC) and the Ministry of Health and the Ministries of Agriculture and Livestock Develop-ment and Community Development, Children and Women's Affairs Mulokozi *et al.*, 2001	Reduce the exposure of foods to contaminants and direct sun, the time needed for drying, and the humidity levels of the foods so that the dried foods could be better stored; Increase women's access to food-processing technologies that extend the avail- ability of vitamin A and provitamin vitamin A–rich foods, reduce nutrient losses due to traditional processing methods, and improve the hygienic and nutritional quality of the dried food products	women	Strengths 1. increased women's productivity and efficiency 2. lighter in weight and portable Limitations 1. the artisans charged inflated prices for their services, which might have discouraged community members from using their service and limited the adoption rate 2. adopters had higher socioeconomic status than nonadopters, a consistently reported pattern in technology development literature	1. Continue to promote the technology 2. Continue to promote production of fresh fruits and vegetables 3. Undertake a longitudinal study to determine if dietary consumption of vitamin A is sustained
health technology	non-electric transport incubator developed by Keele University, by Yassaman Khodadadeh in collaboration with the Ministry of Health of Iran Khodadadeh *et al.*, 2001	The device produces heat via an exothermic crystallisation reaction initiated by a metal disc, similar to that used by commercially available hand warmers. This system is reusable.	nurses	Strengths 1. the new non-electric transport incubator is cheap, easy to use, easy to maintain and repair 2. confirmed its safety and effectiveness in keeping non-distressed babies 3. transferring babies from rural and isolated areas to bigger towns or cities, between health facilities in a town or for indoor transport between different units of a hospital. Limitations 1. has no humidity facility	n/a
health technology	magnifying device (Magnivisualizer) developed by A.P. Parashari *et al.*, 2000	for detecting precancerous lesions of the uterine cervix	medical staff	Strengths 1. detecting most early cancerous and high-grade precancerous lesions that have a high potential for progression in low-resource settings 2. comparatively inexpensive	1. additional requirement is an examination table

Table 2. Continued

Category	Appropriate technology	Product details	User	Evaluation	Recommendations
health technology	autodestruct syringe developed by Program for Appropriate Technology in Health (PATH) Nelson *et al.*, 1999	reduce the improper reuse of syringes	vaccinator	Strengths 1. easier to use, faster, and more accurate than the disposable syringe. Limitations 1. the syringe supply exceeded the disposal-box capacity, resulting in over-filled boxes and protruding syringes	1. care must be taken to ensure compliance with proper disposal techniques
health technology	radiology, Basic Radiological System (BRS) developed by WHO Leggat *et al.*, 1997	the total package include specifications for equipment and battery powered generators to overcome problems of unreliable power supplies, and training manuals for radiographic and darkroom techniques and radiograhic interpretation	health care workers	Strengths a universal standard can help produce specifications for cost-effective radiological imaging systems that can be used in rural areas	purchase an appropriate general purpose X-ray unit and then, as budgets permit, a good general purpose ultrasound unit
health technology	birthweigh scale developed by Program for Appropriate Technology in Health (PATH) of Seattle, Washington (USA) Ritenbaugh *et al.*, 1989	to monitor birthweight in developing countries, where most infants are delivered at home by traditional midwives, could provide an important component in the monitoring of maternal and child health.	traditional practitioners, mothers, and other health care providers	Strengths 1. traditional birth attendants can be provided with the information and tools to identify high-risk newborns and to refer them for further care 2. traditional birth attendants can be provided with the information and tools to identify high-risk newborns and to refer them for further care Limitations 1. reluctance of the dayas to participate or to report low-weight babies: linked to competition between dayas and nurses in communities in which nurses performed up to one-third of deliveries	1. A data collection and management network for reporting from the daya to the health authorities should be tested and the study should be expanded to include other villages 2. need to identify risk factors and high risk areas to permit targeted interventions aimed at prevention
health technology	growth monitoring developed by UNICEF Nabarro *et al.*, 1988	To produce a sensitive indicator in children's health by regularly monitoring children's height and weight	traditional practitioners, mothers, and other health care providers	Strengths 1. Can provide mothers knowledge and support that they require in order to protect their children's growth 2. Can provide doctors information in assessing health and growth of children 3. Can give parents more power, making them less dependent on doctors or clinics Limitations 1. Inadequate participation of international agencies 2. not enough strategies developed for tackling children's nutritional and health problems	Need to answer following questions: What are the risks associated with growth faltering or weight loss? To what extent can different health, educational or welfare interventions reduce these risks? How much will these interventions cost; could the resources (including mothers' time and enthusiasm) be put to better use?
technology	Mohara Water Treatment Plant developed by Water Supply and Sewerage Authority (WASA) Monk *et al.*, 1984	To provide prudent, cost-effective water plant that could be built and operated practically and effectively using native materials and human resources	residents	Strengths 1. Produce reliable treatment, minimize imported items, maximize local labor during construction and operation, limit energy demands, use local materials whenever possible, and provide adequate flexibility Limitations 1. To limit imported items and specify local materials where possible	1. design facilities compatible with local conditions 2. maximize the use of local materials and labor 3. minimize the use of local materials and labor 4. minimize dependence on overseas materials and equipment 5. education programs for local professionals needed 5. research and reevaluation is necessary
health technology	portable coagglutination test kit developed by Centre Muraz laboratory, Naval Health Research Center in California Sanborn *et al.*, 1984	the rapid, bedside diagnosis of cerebrospinal meningitis	local medical attendants	Strengths Diagnosis, better treatment and control of many tropical infections. The kits provided bedside diagnostic information that was immediately useful for patient care.	n/a

Table 3. Implementation Strategies for Appropriate Technologies (n=4)

First Author, Year	Implementation strategies
Morse *et al.*, 2020	1. Determining prototype and promotional approach: Assessment methods 2. Factors influencing prototype development and implementation: Program environment factors, implementer related factors, recipient related factors, contextual factors 3. Promotional approaches: co-designed community SODIS prototype, messaging for technical use of treatment system, promoting use through behavior change techniques 4-1. Outputs and outcomes (short term): Evaluation of acceptability, adaption, dose, engagement, fidelity, reach, satisfaction, recruitment, attrition 4-2. Outputs and outcomes (medium term): behavior change 4-3. Outputs and outcomes (long term): Reducing morbidity and mortality from diarrheal disease
Dunmade *et al.*, 2002	1. Primary indicator: Adoptability 2. Secondary indicator: 1) technical sustainability ((1) the accessibility of component parts, (2) the availability of the needed infrastructure, (3) the availability of technical know-how to accomplish such service (4) the elapsed time between repairs), 2) environmental sustainability ((1) resource consumption, (2) environmental releases, (3) resource conservation, (4) environmental compliance) 3) economic sustainability ((1) affordability, (2) reusability, and (3) local availability of required servicing resources) 4) socio-political sustainability ((1) the level of awareness, (2) acceptability, (3) govern- mental policy and continuity, (4) the socio-cultural influence)
Ong, 1991	Components of work factors in human-machine relationships 1. operator, 2. tool (biomechanical, physical), 3. workstation and environment (biomechanical, anthropometry, workplace design, climate), 4. task (new technology, training, job satisfaction, management system, working hours, shift work)
Free, 1992	1. Design (identify technology), 2. Specifications (identify need), 3. Consensus (collaboration), 4. Product (Manufacture), 5. Demand (promote), 6. Application (introduce)

2. Implementation strategies for appropriate technologies in global health

Table 3 shows the strategies for implementing appropriate technology in global health. The assessment method and factors influencing prototype development and implementation (program environment factors, implementer related factors, recipient related factors, contextual factors) (Morse *et al.*, 2020), adoptability (Dunmade, 2002), design (identify technology), and specifications (identify need) (Free, 1992) are all evaluated as input indicators. Promotional approaches (co-designed community-based prototype, message for technical use of treatment system, promoting use through behavior modification strategies) and process indicators (Morse *et al.*, 2020). Technical, environmental, economic, and socio-political sustainability were identified as essential indicators in the appropriate technology implementation strategies for output criteria (Dunmade, 2002). Ong additionally identified components of work factors in human-machine interactions as crucial implementation indicators (Ong, 1991).

Conclusion

Appropriate technology in global health is a crucial intervention enhancing health in developing countries. In this rapid review, we identified 19 studies to systematically organize the existing appropriate technologies, their evaluation results, and implementation strategies.

In general, research have demonstrated the development of appropriate technologies of use in the field of global health. Additionally, numerous appropriate technologies have been implemented throughout the last four decades and have remained mostly concentrated in a few countries. Most of the research has focused on the deployment and performance of distributed technology in low-resource contexts. According to the analyzed research, the intended users were primarily community residents and health care professionals. However, the examined studies do not include an assessment of long-term health outcomes and they are primarily concerned with short-term outcomes. Furthermore, several implementation strategy components were discovered that might be used to the evaluation criteria.

1. Study Limitation

Our study may be limited by publication bias. This study did not include non-peer-reviewed articles, such as grey literature or program reports, and articles written in language

other than English.

2. Critical components of implementing an appropriate technology in the Global health arena

1) Community participation

Numerous studies in this rapid review have established the significant importance of engaging the community in the application of appropriate technology in low-resource situations. The Alma Ata Declaration of 1978, which established the community as a critical component of primary health care planning, organization, operation, and control, elevated community engagement to a new level (WHO, 1978). Community involvement has emerged as a global health aim in recent years, with the establishment of the new Sustainable Development Goals. Integrated, people-centered health care is crucial for reaching the SDGs' goal of universal health coverage, and accomplishing this goal requires participatory approaches (Marston *et al.*, 2016). Apart from enhancing the efficiency of health initiatives through community participation, it is argued that effectively involving communities improves social capital, leading to increased community empowerment and, eventually, improved health status and reduced health inequities (Morgan, 2001). In this manner, including the community while using appropriate technology to promote health in low-resource settings makes the technology more sustainable.

2) Systems approach

Our findings emphasize the importance of a systems approach to disseminating appropriate technology in global health as shown in Figure 1. Delivering health related appropriate technology in low-resource regions is highly complex, as it requires the convergence of multiple disciplines. Integrative systems-based methodologies such as systems approach are increasingly attracting attention for their ability to promote the

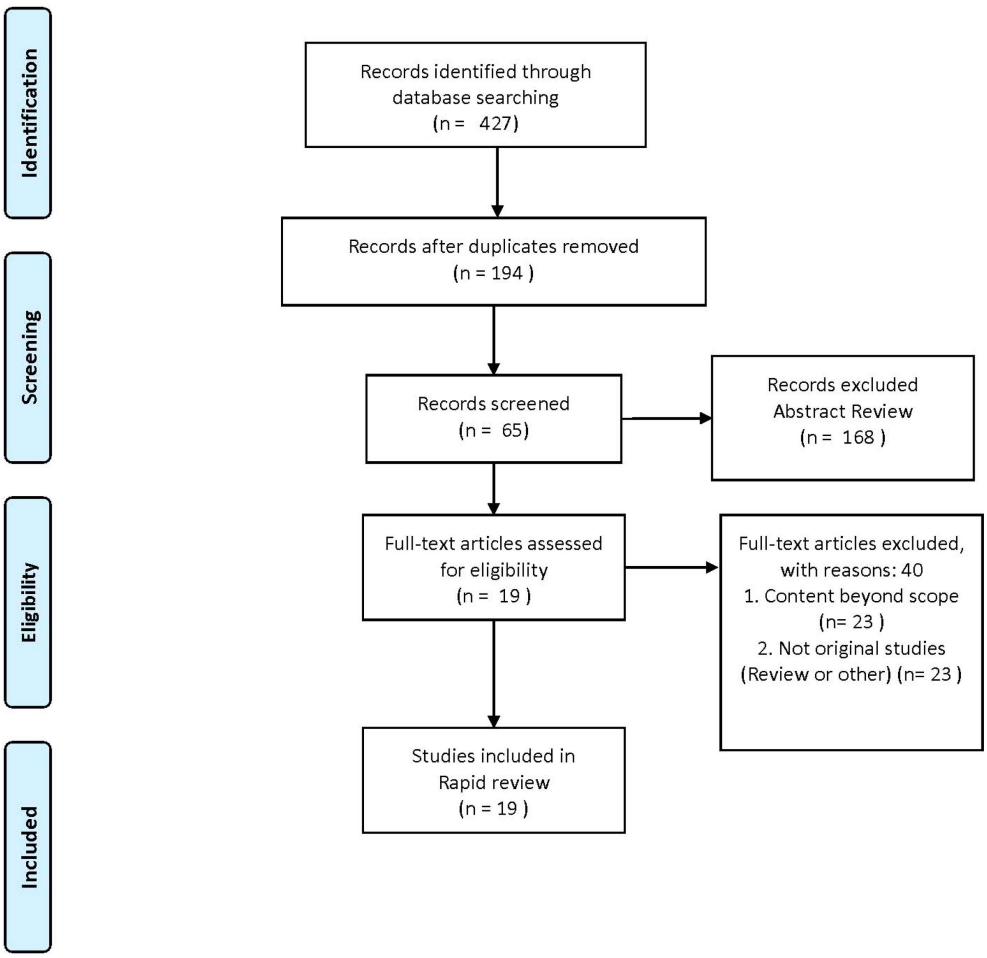

Figure 1. Flow chart of the literature search and screening process

transdisciplinary collaboration (Mercure *et al.*, 2015). One of main parts of systems approach is systems thinking which defined as "an integrated approach to grasping the dynamic linkages between complex economic, environmental, and social systems and assessing the potential consequences of change." (Fiksel *et al.*, 2014) Systems thinking captures how to intervene to improve population's health. Systems thinking to selecting appropriate technology necessitates a scientific understanding of system complexity and an understanding for technology's role in health improvement. As a whole, our understanding of how to adopt appropriate technologies to improve health outcomes will be strengthened by a systems approach.

3) Long term health outcome

Several studies have mentioned short term health outcomes such as improvement of immediate health services, advancement of specificity and sensitivity, and performance of health care technologies (Jeronimo *et al.*, 2014; Labbé *et al.*, 2001; Liang *et al.*, 2018). However, there is a dearth of information on the long-term health outcomes related with appropriate technology intervention. The professional developers must have a firm grasp on the effect that healthy interventions can have on one's prevailing and long-term health. Such studies are necessary to expand the range of possible health outcomes associated with clinical outcomes while including patient satisfaction as an endpoint.

3. Future direction

Various adaptable and low-marginal-cost digital interventions are being proposed as appropriate technologies these days. Digital technologies (apps, wearables, EHRs, and mHealth) have the potential to create a technology-enabled health system in which care exchanges occur outside of hospital settings and community individuals are encouraged to self-manage their health and illness (Greaves *et al.*, 2019). Prior to developing and implementing digital health systems in low-resource settings, it is critical to determine whether an organization, institution, as well as a region or country is prepared to adopt new technology and processes. It is essential to understand the beneficial and negative perceptions of digital health systems among healthcare practitioners, engineers, patients, community residents, and program administrators. Therefore, measuring preparedness is one of the first elements in building a digital health plan for future direction.

Conflicts of Interest: The authors declare no conflicts of interest.

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