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REVIEW

Evaluation frameworks for technology transfer projects: Lessons from Japan's global growth of medical technologies initiatives in low- and middle-income countries

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Abstract: Understanding the evaluation framework for assessing the outcomes of projects following complex technology transfer processes is limited. Therefore, we conducted a study to develop and investigate the validity of performance indicators of the technology transfer process. The performance indicators, consisting of ten indicators each for "health technology" and "health products", were developed using the Delphi method and a relationship diagram was generated. To examine validity, correlations between indicators were analyzed using a questionnaire regarding the essential factors influencing health technology and product transfer. A mutual contributory relationship between indicators related to health technology and products may exist. One of the factors promoting technology transfer was projects lasting three or more years, although no significant correlation was detected between other public support utilization and performance indicators. However, the indicators do not fully cover the technology transfer process, such as the pathway to procurement of "health products." Future research is necessary to improve performance indicators through on-site investigations.

***Keywords*:** health technology, technology transfer, low-and middle-income countries, universal health coverage

Introduction

Goal 3 of the Sustainable Development Goals states that "access to quality essential healthcare services and access to safe, effective, quality, and affordable essential health products such as medicines, vaccines, and medical devices for all" are critical for achieving universal health coverage (*1*). Nevertheless, many low- and middle-income countries (LMICs) lack access to quality public health goods (*2*), resulting in negative effects on health of the population.

Similar to many other countries and organizations, the Japanese government is working to promote the international expansion of health systems, technologies, personnel, and related products to other nations, ensuring mutual benefits for both parties. As part of this effort, the Projects for Global Growth of Medical Technologies has been implemented since 2015 as a grant program by the National Center for Global Health and Medicine (NCGM), which functions as the secretariat, overseeing the management, monitoring, and evaluation of the entire project, handling approximately 30 projects annually in approximately 34 countries (*3*). However, the degree of technology transfer and its contribution to health outcomes vary.

The variability in health outcomes can attribute to the fact that health technologies and products are not always transferred in a manner appropriate for the country (*4*). For example, the establishment of health technologies is affected by several factors, such as needs, training content, and educational system. Furthermore, some health products may remain unused due to a discordance in product needs and a lack of public infrastructure, spare parts, consumables, or trained technicians (*5*), whereas other health products may not comply with local certification systems or the treatment guidelines of local governments. The improper utilization of health products can affect health outcomes (*6*). The equitable delivery of health products and services is becoming increasingly complex owing to pharmaceutical regulations and geographical disparities, as evidenced by the distribution of vaccines and related supplies to combat coronavirus disease 19 (*7,8*).

To delineate the intricate processes associated with access to and delivery of health technologies and products in LMICs, several conceptual frameworks exist,

such as the Consolidated Framework for Implementation Research (*9*) for health technologies and health products, the pharmaceutical value chain by the United Nations (*10*), the modified value chain by the World Health Organization (WHO) (*11*), and the framework by the UN Development Programme Access and Delivery Partnership (*12*). In our previous study (*13*), we proposed seven steps for achieving equitable access to and delivery of health products based on our experience and document review (*14*). However, there is a limited understanding of the performance indicators for assessing the processes of health technology and health product transfer in one framework. We reviewed key lessons from the development and validation of performance indicators for projects transferring health technology to LMICs. Furthermore, it served as a case study to examine the validity of the Projects for Global Growth of Medical Technologies.

Development of performance indicators

The performance indicators for projects involving transfer of health technology and health products were developed from two perspectives: the technical aspect (hereinafter "health technology") and the deployment of health products (hereinafter "health products" in this paper) using the Delphi method (*14*). Specifically, we posed questions about essential factors influencing health technology and product transfer to several experts with experience in technical cooperation projects in LMICs from the NCGM using a questionnaire developed in this research (Supplemental Table S1, *https://www.ghmopen.com/site/supplementaldata.html?ID=100*). The responses were categorized into performance indicators under expert consensus and organized as part of the health technology and product transfer process. Subsequently, the drafted performance indicators were reviewed by experts and finalized. A diagram to describe the relationship (hereinafter "relationship diagram") between the indicators was also developed.

Furthermore, in order to examine validity of the performance indicators, the correlations between indicators according to the "relationship diagram" were analyzed using actual health technology transfer projects. For this purpose, a questionnaire was developed to evaluate the Projects for Global Growth of Medical Technologies that support human resource development (HRD) by providing training for key staff using targeted health technology and health products in recipient countries (Supplemental Table S1, *https://www.ghmopen.com/site/supplementaldata.html?ID=100*). We obtained responses from project representatives between 2017 and 2022 using an online tool, viz. Microsoft Forms. Projects conducted over multiple years on the same theme were treated as a single project for evaluation purposes. Additionally, we collected background information on the target region, target technology/products, project duration, and utilization of other public support.

Thereafter, the percentage of projects relevant to each performance indicator were calculated among all projects for "health technology" indicators and among the projects handling health products for "health product" indicators. Responses marked as "unknown" for each performance indicator was considered as not having met the indicator at the time of evaluation. Correlations were statistically assessed using the chi-squared test. The nature of the performance indicators was investigated by examining the factors influencing them. Collected data were analyzed using Microsoft Excel 2021.

This study was approved by the ethics review board of the NCGM (NCGM-S-004703-00).

Structure of Performance indicators to evaluate projects of technology transfer to LMICs

Ten performance indicators were identified for "health technology", including 7 process indicators and 3 outcome indicators. Similarly, 10 performance indicators were identified for "health products", which included 6 process indicators and 4 outcome indicators. The outcome indicators were "increased patient access", "improved health impact", "sales increase", and "spread to other countries". These indicators are shown in Table 1, while the "relationship diagram" is depicted in Figure 1.

Evaluation of the Projects for Global Growth of Medical Technologies for the validation of performance indicators

Characteristics of the projects

Eighty-four Projects for Global Growth of Medical Technologies were identified between 2017 and 2022 and representatives of 72 (85%) projects responded to the survey for validation of performance indicators. Figure 2 shows the distribution of the projects' target countries. Asia had the highest percentage of projects at 88%, followed by Africa at 10%. Within Asia, Vietnam had the highest number of projects, followed by Myanmar and Mongolia, respectively. Table 2 illustrates characteristics of the projects. In terms of clinical departments, projects dealing with surgical technology were the most numerous, followed by those pertaining to emergency care and infectious diseases. In the paramedical sector, projects focusing on diagnostic testing technology were the most common, followed by educational support and rehabilitation projects. Fifty-one (70.8%) projects entailed the handling of health products; the breakdown is shown in Supplemental Table S2 (*https://www.ghmopen.com/site/supplementaldata.html?ID=100*). Endoscopy-related projects were the most common, followed by ultrasound, pharmaceutical, and diagnostic equipment projects. Thirty-nine projects (54.2%) lasted 1-2 years, whereas 33 projects (45.8%) lasted 3 years

Table 1. Performance indicators of projects for technology transfer to LMICs

Health technology

No.		Indicators	Description
1	Process	Improved knowledge	Improved understanding of health technology and development of personnel capable of diagnosing and treating patients using health technology
2		Dissemination of knowledge	Dissemination of requisite knowledge and skills for use of health technology by trained health personnel to others
3		Continuous use of training materials	Continued local use of already developed training materials for health technology
4		Guideline	Reflection of health technology in guidelines of government or academic society
5		Education program	Incorporation of health technology into the educational programs for health professionals
6		Professional organizations	Establishment of health professional systems and organizations related to the health technology
7		Human resource development (HRD) using a local budget	Use of local government budgets to train health personnel in the use of the health technology
8	Outcome	Increased patients	Increased in number of patients who received diagnosis and treatment related to the health technology
9		Health impacts	Realization of health impact created by the health technology (decreased mortality or morbidity, improved QOL, *etc.*)
10		Spread to other countries (health technology)	Implementation of activities that disseminated health technology beyond the target country (contribution to international guidelines, dissemination to other countries, input in international conferences, *etc.*)

Health products

No.		Indicators	Description
11	Process	Regulatory authorization	Notified body of the target country granted approval/license for the health product
12		Health insurance coverage	Health insurance started to cover health product
13		Listing of health products	National medical device list started to cover health product
14		Local distributor	Local distributer was established/identified for the health product
15		Procurement by local budget	Health product was procured by a local budget in target country
16		Continuous use of health product	Health product was continuously used in target country
17	Outcome	Increased patients	The number of patients who received diagnosis and treatment related to the health technology increased
18		Health impact	The health technology created health impacts (decreased mortality or morbidity, improved QOL, *etc.*)
19		Sales increase	The health product was continuously marketed in target country
20		Spread to other countries (health product)	The health product was procured in areas other than target country

QOL: quality of life, LMIC: low- and middle-income countries.

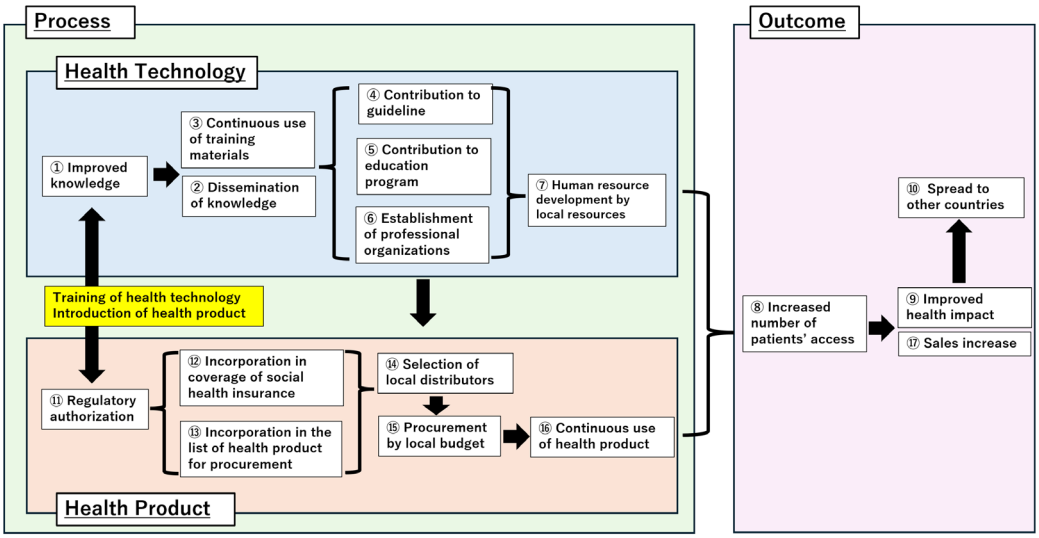

Figure 1. Relationship of performance indicators.

or more. Twenty-five projects answered affirmatively regarding utilization of other public support, accounting for 34.7% of the total.

Project evaluation by the performance indicators

The results of the evaluation of the Project for Global Growth of Medical Technologies are presented in Table 3. For "health technology", projects pertaining to the dissemination of knowledge/skills and continuous use of training materials accounted for 45 (62.5%) and 29 (40.3%) of 72 projects, respectively. HRD system was defined by the presence of at least one of the following performance indicators: incorporation into educational programs, establishment of academic societies/professional organizations, and incorporation into guidelines, and 30 projects met this indicator (41.7%). By the end of the project, the recipient country's government had independently organized training in 34 projects (47.2%). Outcome indicators, such as increased number of patients and manifestation of health impact, were reported in 27 (37.5%) and 20 (27.8

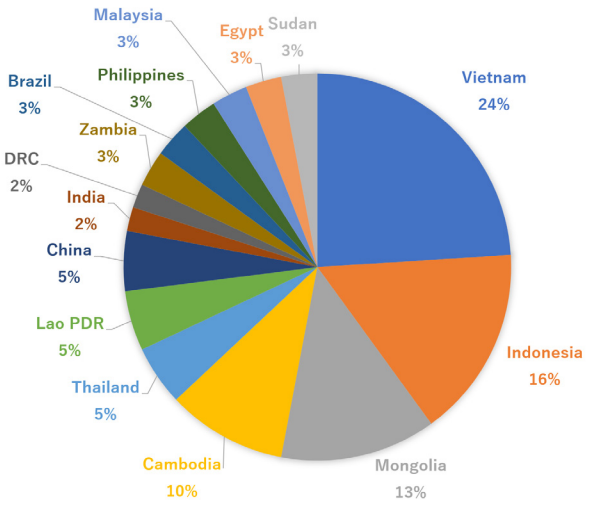

Figure 2. Distribution of target countries of the Projects for Global Growth of Medical Technologies between 2017-2021.

Table 2. Characteristics of the Projects for Global Growth of Medical Technologies between 2017-2021

Characteristics	Projects
Duration, Cases (%)	
One year	26 (36.1%)
Two years	13 (18.1%)
More than three years	33 (45.8%)
Other public supports	
Yes	25 (34.7%)
No	47 (65.3%)
Themes: Clinical Department	
Surgery	8
Emergency	6
Infectious disease	5
NCDs, mental and advanced medicine	4
Health check-up	4
Cancer	3
MCH	3
General medicine	1
Themes: Paramedical sector	
Diagnostics	8
Education	5
Rehabilitation	5
Radiology	5
Medical Equipment engineering	4
Dialysis	4
Blood transfusion	3
Endoscopy	2
Pharmaceutical management	2

Table 3. Results of evaluation for the Projects for Global Growth of Medical Technologies

Results	Projects
Health technology (72 projects in total)	
① Improved understanding of health technology	72 (100%)
② Dissemination of knowledge/skills	45 (62.5%)
③ Continuous use of training materials	29 (40.3%)
④ Incorporation into education programs	24 (33.3%)
⑤ Establishment of academic society/professional organization	5 (6.9%)
⑥ Incorporation into guideline	13 (18.1%)
⑦ Human resource development (HRD) using the local budget	34 (47.2%)
⑧ Increased number of patients	27 (37.5%)
⑨ Manifestation of health impact	20 (27.8%)
⑩ Activities that spread the health technology beyond the target country	24 (33.3%)
Health product (total: 51)	
⑪ Acquisition of a license of the health product	5 (9.6%)
⑫ Acquisition of health insurance coverage of the health product	3 (5.9%)
⑬ Inclusion of the health product in the list of medical devices	2 (3.9%)
⑭ Selection of local distributors for the health product	7 (13.5%)
⑮ Procurement of the health product by local budget	23 (42.3%)
⑯ Continuous use of the health product	32 (61.5%)
⑰ Increased sales of the health product	8 (15.4%)
⑱ Procurement of the health product in other countries.	6 (11.5%)

%) projects, respectively. Additionally, among the 51 projects dealing with health products, 23 (42.3%) led to procurement, and 32 (61.5%) reported continuous usage. Eight projects (15.4%) increased sales of health products. However, questions regarding sales improvements were challenging to answer, leading to difficulties in evaluation.

Correlations between performance indicators

Figure 1 shows correlations between the indicators. Table 4A shows the relationship between the HRD system and the outcomes of health technology and health product transfer. The HRD system was statistically associated with outcome indicators, such as HRD by local budget, increased number of patients, and health impact. Similarly, regarding "health product" indicators, Table 4B shows the relationship between procurement by local budgets and outcomes of heath technology and health product transfer. Procurement based on local budgets was significantly associated with continuous use and an increase in the number of patients. Additionally, the mutual relationship between indicators of "health technology" and "health products" was analyzed (Table 4C). Among the 24 projects that established an HRD system, 15 (51.7%) and 18 (75%) led to the procurement of health products and their continuous usage, respectively. These figures are statistically greater for procurement in projects with HRD systems compared with projects that did not establish HRD systems.

Table 4A. Relationship between human resource development system and the outcome of technology transfer (number of projects)

HRD System*	Local budget use		Increased patients		Positive health impact	
Established (30)	20	66.7%	16	53.3%	13	43.3%
No Established (42)	14	33.3%	11	26.2%	8	19.0%
p value**		< 0.05		< 0.05		< 0.05

*HRD system was characterized by the inclusion of at least one of the following: Incorporation into education programs, establishment of academic society/professional organization, or incorporation into guidelines. ***p* value is calculated by chi-square test.

Table 4B. Relationship between procurement using local budgets and the outcome of technology transfer among projects that included health products (number of projects)

Procurement*	Continuous use		Increased patients		Positive health impact	
Procurement (23)	18	78.2%	15	65.%	10	43.5%
Non-procurement (28)	14	50%	10	35.75	8	28.6%
p value**		< 0.05		< 0.05		0.268

*Procurement: Procurement of health product using the local budget. ***p* value is calculated using chi-squared test.

Table 4C. Relationship between "health technology" and "health product" in the 51 projects that included medical products (number of projects)

HRD system*	Procurement		Continuous use	
Established (24)	15	51.7%	18	75.0%
Not established (27)	8	36.4%	14	57.2%
p value**		< 0.05		0.088

*HRD system was characterized by the inclusion of at least one of the following: Incorporation into education programs, establishment of academic society/professional organization, or incorporation into guidelines. ***p* value calculated using chi-squared test.

Table 4D. Relationship between performance indicators and characteristics (number of projects)

	All projects (72)				Projects which treated medical devises (51)				
	HRD system (30)		Local budget use (34)			Procurement (23)		Continuous use (32)	
Duration of projects					*Duration of projects*				
1-2 years (39)	12	30.1%	14	35.9%	1-2 years (22)	7	31.8%	10	45.5%
≥ 3 years (33)	18	54.5%	20	60.1%	≥ 3 years (29)	16	55.1%	22	75.9%
p value*		< 0.05		< 0.05			0.10		< 0.05
Utilization of other public supports									
Yes (25)	15	60.0%	6	24.0%	Yes (18)	7	38.9%	14	77.8%
No (47)	25	53.2%	7	14.9%	No (33)	16	48.5%	18	54.5%
p value*		0.58		0.34			0.51		0.10

**p* value calculated using chi-squared test.

Factors influencing performance indicators

Table 4D summarizes analysis of the relationship between project characteristics and their outcomes. When comparing projects lasting to 1-2 years with those lasting 3 years or more, the latter exhibited a tendency towards higher performance indicators in terms of incorporation into the education system or guidelines and procurement/ continuous usage, with statistically significant differences in other areas apart from procurement. However, no statistically significant differences were evident in the utilization of other types of public support for any performance indicator.

Interpretation of the evaluation for the indicators' validation

In this study, the performance indicators for projects transferring health technology and health product to LMICs were developed from the dual-perspective of "health technology" and "health products". Based on evaluation of an actual project, the association between the performance indicators was statistically proved using the "relationship diagram". We confirmed the validity of the developed performance indicators to describe processes of health technology and health product transfer. With reference to the "relationship diagram" representing the steps from the introduction to the institutionalization of "health technology" and "health products", each project was evaluated according to its nature and stage of development. Furthermore, analysis of performance indicators of "health technology" and "health products" revealed mutual relationships between them. The results suggest that the integration of "health technology" into the local healthcare system is crucial for procurement and establishment of "health products" for further business development. These indicators were useful in visualizing outcomes of the complex process of technology transfer, laying groundwork for necessary interventions.

Moreover, these performance indicators were useful for investigating the factors contributing to each process of health technology and health product transfer. The results of the evaluation of the Projects for Global Growth of Medical Technologies over the past five years revealed that the duration of the project influenced performance indicators of both "health technology" and "health products". Specifically, projects lasting three or more years exhibited significantly higher performance indicators, suggesting that approximately three years may be required to achieve sufficient results. The transfer of new technology requires building relationships with local stakeholders and integrating them into the local healthcare system, which is a time-consuming process. This may explain the results of the present study. However, there was no significant correlation between utilization of other public support systems and any performance indicator. Although we hypothesized that the effective utilization of multiple public support systems could yield better outcomes, this was not demonstrated in this study's analysis. However, the factors affecting the complicated process of health technology and health product transfer can be analyzed in greater detail using this framework.

Limitations

This study has several limitations. First, data collection on performance indicators solely through surveys of project implementers may be insufficient, and some indicators may require in-depth, on-site information gathering. For example, evaluating indicators such as the health impact after the introduction of "health technology" or "health products" is time-consuming. Therefore, it is necessary to include field visit surveys with local users of health technology and health products to consider the feasibility of data collection methods and examine the validity of performance indicators. Additionally, when respondents answered "unknown" to a question in the questionnaire, we classified it as "no achievement". However, there were many such responses (11 procurement projects and 26 guideline-creating projects). Therefore, local surveys or in-depth questionnaires are necessary to investigate projects with "unknown" responses. Furthermore, although we examined the factors influencing performance indicators, we could only conduct simple analyses using chi-squared tests owing to an insufficient number of projects, and analyses adjusting for confounding factors could not be performed. In the future, we endeavor to increase the number of projects and further investigate the various promoting and hindering factors.

Conclusion

We developed performance indicators for projects transferring health technology to LMICs. Based on actual project evaluations, the validity of these indicators was satisfactory. From the perspective of the complex process of technology transfer, comprehensive evaluations tailored to the nature and stage of the projects can be conducted. However, it was difficult to adequately evaluate some indicators by simply posing questions to project implementers. Therefore, in the future, we aim to further examine validity of performance indicators and explore factors that facilitate or hinder further development of projects, potentially combining them with local investigations.

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