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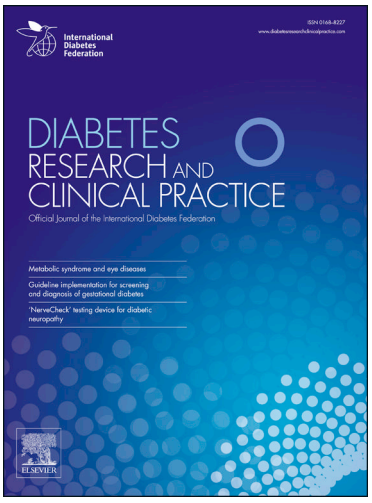

Documenting and visualising progress towards Universal Health Coverage of insulin and blood glucose test strips for people with diabetes

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Doc **rips for people with diabetes**

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Author's contributions

ELK compiled the data, conducted the analysis, and wrote the first draft of the paper. MM conceived the self-sustainability assessment and substantially contributed to the manuscript. GDO conceived the study and co-wrote the manuscript.

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Abstract

Aims

Global governments have committed to achieve Universal Health Coverage (UHC), ensuring access to quality and affordable healthcare for all. This is fundamental for those with type 1 diabetes mellitus, who require daily access to both insulin and blood glucose test strips to survive. This group risks being left behind by global initiatives that fail to consider these particular needs.

Methods

A questionnaire was distributed to key informants in 37 less-resourced countries. Seven high-income countries were also included for comparison. We drew on a WHO framework developed to assess progress towards UHC to create scales on three dimensions: population covered, services provided and direct costs. A fourth dimension, availability, was added. Results were grouped into six patterns and visually displayed with radar graphs.

Results

65% of the less-resourced national health systems provided insulin, with medians of 67% for service provision (equating to Human Regular and NPH), 55% direct costs covered, and 75% availability. Test strips were only provided in 14% of the less-resourced systems, with medians 42% (less than two strips per day), 76%, and 88% respectively. Six patterns of provision were identified. Progress correlated with income level, yet some low-income countries are achieving provision for insulin and test strips for those enrolled in health insurance schemes.

Conclusion

No less-resourced country had even near-complete coverage for insulin, and coverage was worse for test strips. This study demonstrates the utility of this framework which could be developed as a means of tracking progress in meeting the needs of people with diabetes.

Keywords: Universal Health Coverage, Sustainable Development Goals, Diabetes, Type 1 Diabetes, Insulin, Blood Glucose Monitoring

1. Background

People with type 1 diabetes mellitus (T1DM) face severe risks if they cannot access insulin and test strips. Although their situations have improved greatly in some countries [1], many still face the prospect of premature death and severe complications because of an inability to secure reliable and affordable supplies of these products.[2–8] Fortunately, health is now high on the global agenda, with *Goal 3* of the United Nations' Sustainable Development Goals calling on governments to ensure healthy lives and promote wellbeing for all at all ages[9] by meeting targets including *Target 3.4,* "reduce by one-third premature mortality from non-communicable diseases through prevention and treatment…"[9]; and *Target 3.8,* "achieve universal health coverage (UHC), including financial risk protection, access to quality essential health-care services, and access to safe, effective, quality, and affordable essential medicines and vaccines for all"[9].

These commitments have stimulated numerous initiatives to develop and strengthen health financing and delivery systems but there is a risk that the very specific needs of the estimated 425 million people worldwide who have diabetes, 80% of whom live in low-and middle-income countries, could be overlooked[10]. Providing diabetes care has many challenges, including for instance procuring, storing, and distributing a product such as insulin that requires a complex management system, including a cold chain. It has been previously shown that access to crucial medical supplies for people with diabetes varies globally.[1,8,11–13]

Coverage by health services has several dimensions. This is commonly represented by means of a cube (Figure 1),[14,15] with three dimensions: population covered, services or treatments covered, and share of the direct cost covered by the health system.

2. Methods

A self-assessment questionnaire on sustainability, distributed to diabetes centres supported by the International Diabetes Federation Life for a Child Program (LFAC) in 2016-17, was the primary source of data. The instrument included a range of questions on aspects of national health systems, and government supply of insulin and test strips, and their costs and availabilities in national health systems, private and public retail pharmacies, and health insurance schemes. Before distribution it was reviewed by experts in diabetes access in less-resourced countries, and was distributed in English, French and Spanish.

The self-assessment was completed by the senior person in the organization supported by LFAC that provided clinical care to young people with diabetes in that country. The self-assessment was distributed to 37 countries: Azerbaijan, Bangladesh, Bolivia, Burkina Faso, Burundi, Cambodia, Central African Republic, Democratic Republic of Congo, Dominican Republic, Ecuador, Eritrea, Ethiopia, Ghana, Guatemala, Guyana, Haiti, Jamaica, Kenya, Liberia, Maldives, Mali, Mauritania, Mexico, Nepal, Nigeria, Pakistan, Philippines, Republic of Congo, Rwanda, Sri Lanka, Sudan, Tajikistan, Tanzania, Togo, Uganda, Uzbekistan, and Vietnam.

Questions included end-user costs of 10mL of insulin (analogue or human long/short acting or pre-mixed insulin as applicable) and blood glucose testing strips. Costs were obtained in local currency and then converted to US$ at the time. When prices were reported as a range, the lowest value was used for analysis. When necessary, follow up questions were clarified. Information on coverage, provision, costs, and availability was also collected from senior diabetes figures in Australia, France, Italy, Japan, New Zealand, Sweden, and the United Kingdom.

Provision of services was defined as insulin and strips being supplied through the public health system. Each dimension was defined as a percentage as follows:

Population was defined as the percentage of the population who can potentially access the public health service. When health system coverage was not universal, figures were corroborated by published sources where possible.

Many countries have a variety of health systems, including private insurance schemes used predominantly by the wealthy or have services exclusively accessed by certain groups such as armed forces. In this study, we reviewed those government health systems in which a substantial proportion of the population was enrolled. For instance, two in particular had several systems that each covered a substantial share of the population, with differing eligibility and entitlements. Mexico has three large systems: IMSS for private sector employees and dependents (enrolment 58.9% of the population), ISSSTE – for public sector employees and dependents (10.6%) and the basic national health system Seguro Popular for those not covered by IMSS or ISSTE (44.9%) (There is some overlap in enrolment between the systems). [16]. In Tanzania, the National Health Insurance Fund (NHIF) is mandatory for public servants and their dependents[17] and is also available for other workers if they can afford membership fees. Enrolment was noted to be 7.2% in 2014[18], with the Tanzanian in-country investigator reporting a rise in this figure to 27% in 2017. The remainder of the population have access to the basic national public health system.

For Services, two empirical scales were developed: for insulin, we used a four point scale, which we expressed as a percentage, with the provision of analogue insulin scaled 100%, NPH and regular 67%, pre-mixed only 33.3%,

and none 0%; for test strips, provision was expressed on a five point scale as 100% for four or more test strips/day, 75% for three/day etc., with 0% for no provision.

Direct cost was calculated as the out of pocket cost people with diabetes pay for services in the public health system divided by the costs of those same services when purchased completely out of pocket (retail cost at a private pharmacy).

Availability was estimated by the country correspondent from a scale of 100% being always available, 75% mostly available, 50% sometimes available, 25% rarely available, and 0% never available.

2016 Gross National Income per capita, atlas method (current US$)[19] and World Bank country income level classifications were used.[19]

Radar graphs were developed in Microsoft Excel to provide a visual representation of provision for insulin and test strips in each country. Provision was represented by shading within an equilateral triangle (Figure 2.)

The three WHO UHC dimensions were each represented by distance from the middle of the triangle to the respective point of the triangle, and the area included was shaded. Then availability, as the fourth dimension, was designated by a particular colour of a traffic light system. Green shading indicates 100% availability, light green 75-100%, amber 50-75%, light red 25-50%, and dark red 0-<25%.

3. Results

37 countries returned the self-assessment by January 2018. The geographic distribution was Africa (18 countries), Americas (8), Asia (7), Caucasus/Central Asia (3), and Western Pacific (1).

Respondents included: one mission hospital with the largest type 1 diabetes clinic in the country (Liberia), two Ministry of Health contacts (Burundi and Guyana), four senior endocrinologists (Azerbaijan, Ghana, Pakistan, and Philippines), five diabetes nongovernmental organisations doing extensive work in diabetes care (Burkina Faso, Democratic Republic of Congo, Dominican Republic, Guatemala, and Mali), six government hospitals (Kenya, Nepal, Nigeria, Sudan, Tajikistan, and Vietnam), and 19 national diabetes association chiefs (Bangladesh, Bolivia, Cambodia, Central African Republic, Ecuador, Eritrea, Ethiopia, Haiti, Jamaica, Maldives, Mauritania, Mexico, Republic of Congo, Rwanda, Sri Lanka, Tanzania, Togo, Uganda, and Uzbekistan).

The self-assessment questionnaire was also completed by diabetes experts in seven High-income countries (HICs) in Australia, France, Italy, Japan, New Zealand, Sweden, and the United Kingdom.

3.1 Population coverage in Public Health Systems

All of the less-resourced countries had some form of national public health system. However, due to geographic distance or civil disturbance (e.g. Mali), incomplete enrolment in health insurance programs (e.g. Mutuelle de Santé in Rwanda, National Health Insurance Fund in Tanzania and National Health Insurance Schemes in Ghana and Kenya), use of private health care (e.g. Ecuador), and other reasons, the coverage in the public health sector was less than 100% in some countries.

3.2 Services, Cost and Availability

3.2.1 Insulin

In the 37 less-resourced countries, 24 (65%) of the profiled health systems provided insulin, with medians of 67% service provision and 55% direct costs covered, and 13 (35%) did not. Human pre-mixed insulin only was provided in two countries and NPH and regular in 20 countries. Two provided analogue insulin (10 mL 100 IU equivalent) at a modest cost (Azerbaijan [$25.00 USD] and Vietnam [$12.18 USD]). For the 24 countries that provided insulin, eight covered 100% of the costs, nine part of the costs, and seven none of the costs (Table 1). Availability ranged from 25% in Sri Lanka to 100% in Burundi, Mexico, and Tajikistan (median 75%).

Although Mexico's basic health system, Seguro Popular, only provided pre-mixed insulin, the other Mexican health systems IMSS and ISSSTE provided NPH insulin to members. The basic public health system in Tanzania provided insulin with a 64% subsidy and the NHIF provided NPH insulin free of charge.

In the 13 countries where governments did not provide insulin, out-of-pocket costs for a 10mL vial of insulin ranged from $3.84 to $34.09 (median $9.04, mean $12.55).

The seven HICs all had 100% coverage through the respective national health system, with co-payments being required in two countries. Table 1 reports further details.

Table 1

Title: Details by country for progress towards UHC for insulin and test strips in type 1 diabetes

				INSULIN				STRIPS			
Country	**Pattern**	**GNI per capita (USD)**	**Health system population coverage**	**Provision**	**Cost covered**	**Availability**	**Cost 10 ml. vial NPH accessed at private pharmacy (USD)**	**Provision**	**Cost covered**	**Availability**	**Cost of one blood glucose test strip accessed at private pharmacy (USD)**
LESS-RESOURCED COUNTRIES											
Azerbaijan*	N/A	$4,760	100%	100%	0%	100%	$25.00	3%	100%	100%	$0.70
Bangladesh	6	$1,330	100%	0%	N/A	N/A	$8.61	0%	N/A	N/A	$0.27
Bolivia **	6	$3,070	57%	0%	N/A	N/A	$20.28	0%	N/A	N/A	$0.62
Burkina Faso	6	$640	100%	0%	N/A	N/A	$8.82	0%	N/A	N/A	$0.54
Burundi	5	$280	100%	67%	25%	100%	$8.00	0%	N/A	N/A	$0.38
Cambodia	6	$1,140	100%	0%	N/A	N/A	$11.50	0%	N/A	N/A	$0.30
Central African Republic	6	$370	100%	0%	N/A	N/A	$13.30	0%	N/A	N/A	$1.00
Congo, Dem. Rep.	6	$420	100%	0%	N/A	N/A	$4.00	0%	N/A	N/A	$0.50
Congo, Rep.	6	$1,710	100%	0%	N/A	N/A	$3.84	0%	N/A	N/A	$0.32
Dominican Republic	4	$6,390	100%	67%	91%	75%	$28.16	0-75%	100% (if provided)	Depends on hospital	$0.82
Ecuador **	4	$5,820	63%	67%	100%	62.5%	$22.00	0%	N/A	N/A	$1.07
Eritrea	5	N/A	100%	67%	0%	75%	$3.43	0%	N/A	N/A	$0.59
Ethiopia**	5	$660	95%	67%	46%	50%	$5.66	0%	N/A	N/A	$0.65
Ghana National Health Insurance Scheme	5	$1,380	36%[20]	67%	0%	50%	$13.29	0%	N/A	N/A	$1.11
Guatemala	6	$3,790	100%	0%	N/A	N/A	$34.09	0%	N/A	N/A	$0.48
Guyana	3	$4,250	100%	67%	100%	90%	$20.00	42%	100%	90%	$0.48
Haiti	6	$780	100%	0%	N/A	N/A	$9.25	0%	N/A	N/A	$0.51
Jamaica	3	$4,660	100%	67%	100%	75%	$20.00	42%	52%	25%	$0.54

Kenya National Health Insurance Fund ***	5	$1,380	13%[21]	67%	40%	75%	$9.64	0%	N/A	N/A	$0.58
Liberia**	6	$370	60%	0%	N/A	N/A	$23.28	0%	N/A	N/A	$1.06
Maldives****	5	$7,430	78%[22]	67%	100%	50%	$20.13	0%	N/A	N/A	$0.71
Mali**	5	$750	75%	67%	0%	90%	$6.59	0%	N/A	N/A	$1.65
Mauritania	6	$1,120	100%	0%	N/A	N/A	$4.45	0%	N/A	N/A	$0.33
Mexico Seguro Popular*****	4	$9,040	45%[16]	33%	100%	100%	$16.17	0%	N/A	N/A	$0.38
Mexico IMSS*****	4	$9,040	59%[16]	67%	100%	100%	$16.17	0%	N/A	N/A	$0.38
Mexico ISSSTE*****	4	$9,040	11%[16]	67%	100%	100%	$16.17	0%	N/A	N/A	$0.38
Nepal	6	$730	100%	0%	N/A	N/A	$5.85	0%	N/A	N/A	$0.56
Nigeria	6	$2,450	30%	0%	N/A	N/A	$7.80	0%	N/A	N/A	$0.56
Pakistan	4	$1,510	100%	67%	100%	75%	$6.13	0%	N/A	N/A	$0.25
Philippines	5	$3,580	61%[23]	67%	0%	N/A	$4.01	0%	N/A	N/A	$0.39
Rwanda Mutuelles de Santé**	4	$700	75%	67%	90%	75%	$8.53	0%	N/A	N/A	$0.37
Sri Lanka	5	$3,780	100%	33%	100%	25%	$19.74	0%	N/A	N/A	$0.33
Sudan (Khartoum only)	5	$2,140	90%	67%	67%	50%	$9.00	0%	N/A	N/A	$0.36
Tajikistan	5	$1,110	100%	67%	15%	100%	$9.00	0%	N/A	N/A	$0.45
Tanzania National Health Insurance Fund**	3	$900	27%	67%	100%	100%	$6.16	21%	100%	100%	$0.88
Tanzania**	3	$900	73%	67%	64%	100%	$6.16	50%	50%	100%	$0.88
Togo	5	$540	100%	67%	0%	75%	$7.87	0%	N/A	N/A	$0.54
Uganda	5	$660	100%	67%	0%	75%	$4.71	0%	N/A	N/A	$0.28
Uzbekistan	4	$2,220	100%	67%	100%	75%	$2.97	0%	N/A	N/A	$0.42

Vietnam**	5	$2,050	90%	100%	8%	100%	$13.23	0%	N/A	N/A	$0.47
HIGH-INCOME COUNTRIES											
Australia*†	2	$54,420	100%	100%	91%	100%	$54.17	100%	76%	100%	$0.40
France*	1	$38,950	100%	100%	100%	100%	N/A	100%	100%	100%	N/A
Italy *	1	$31,590	100%	100%	100%	100%	N/A	100%	100%	100%	N/A
Japan *	2	$37,930	100%	100%	70%	100%	$47.25	100%	70%	100%	$0.71
New Zealand*‡	2	$39,070	100%	92%	100%	100%	N/A	100%	92%	100%	N/A
Sweden*	1	$54,630	100%	100%	100%	100%	N/A	100%	100%	100%	N/A
United Kingdom*‡	1	$42,390	100%	100%	100%	100%	N/A	100%	100%	100%	N/A

* Costs of analogue insulin, not NPH

**Health system population coverage estimated by in-country investigator

***Population enrolment in the health service does not include dependents of members

****Cost of one 3ml cartridge, not 10 ml. vial

***** Population coverage between Seguro Popular, IMSS, and ISSSTE exceeds 100% due to enrolment overlap between systems. Prices recorded were reported from respondents in Nuevo Leon, Mexico. The price situation may vary across Seguro Popular, IMSS, and ISSSTE across other states in Mexico. Respondent noted availability may be subject to individual prescribing circumstances.

† (Australia) Prices as per the National Diabetes Services Schemes (NDSS). There is an annual Safety Net Threshold of 1,138 USD (1,495 AUD).[24]

‡ (NZ) Assumption based on six vials of testing strips provided at one time for patients on insulin. Prescriptions are regulated by PHARMAC and the fully subsidised analogue insulins and test strips are brand-limited. Only one type of test strip is subsidised - an example of competitive bidding.[8] Prescription fees for insulin and test strips are 3.60 USD (5.00 NZD).[25] After 20 prescriptions in a 12 month period a subsidy permits free prescriptions.[25]

‡ (UK) Prescription fees are 11.81 USD[26] (8.90 GBP), but people with diabetes can obtain a medical exemption certificate.

3.2.2 Test strips

Only five (14%) of the 37 less-resourced countries provided blood glucose testing strips in their basic health systems, with medians of 42% service provision, 76% costs covered, and 88% availability. These included Guyana, Dominican Republic, Jamaica, Azerbaijan, and Tanzania. All, however, had limits on the quantities prescribed and entitlements varied. In Guyana, only young people with T1DM were eligible to receive strips, to a maximum of 50 per month at no cost, with 90% availability. In the Dominican Republic, public hospitals in the capital provided a variable number of strips per day (up to three in some situations) at no cost with good availability. In Jamaica, test strips were moderately subsidised (56%) in the public health system, and people with diabetes were eligible to access 50 strips per month. However, availability of strips was estimated to be erratic (10% and limited to the capital city). In Azerbaijan, 50 strips per year were provided, fully subsidised, and always available. Test strips could be accessed in Tanzania's basic public health system, where the cost was subsidised 50% and availability 75%. Tanzania's NHIF provided 25 strips per month with full availability and no co-payment.

Out-of pocket costs for one test strip ranged from $0.25 to $1.65 (median $0.49, mean $0.56).

The seven HICs all had essentially 100% coverage through the respective national health system, with co-payments being required in two countries (Table 1).

3.3 Patterns

We grouped countries into patterns based on population coverage, services, costs, and availability (Table 2).

Table 2

Title: Patterns of progress towards Universal Health Coverage for insulin and test strips in type 1 diabetes

	Population coverage	INSULIN			STRIPS		
		"Services" – type of insulin	Direct cost covered	Availability	"Services" – strips provided per day	Direct cost covered	Availability
Pattern 1: France, Italy, Sweden, United Kingdom	100%	100%	100%	100%	100%	100%	100%
Pattern 2: Australia, Japan, New Zealand	100%	100%	70-92%	100%	100%	70-92%	100%
Pattern 3: Dominican Republic, Guyana, Jamaica, Tanzania National Health Insurance Fund, Tanzania Public Health System	27-100%	67%	64-100%	75-100%	0-42%	50-100%	25-100%
Pattern 4: Ecuador, Mexico (Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado, Instituto Mexicano del Seguro Social, Seguro Popular), Pakistan, Rwanda (Mutuelles de Santé), Uzbekistan	75-100%	33-67%	90-100%	62.5-100%	0%	0%	0%
Pattern 5: Eritrea, Ethiopia, Ghana, Kenya National Health Insurance Fund, Mali, Maldives (Aasandha), Philippines, Sri Lanka, Sudan, Tajikistan, Togo, Uganda,	13-100%	33-67%	0-100%	25-100%	0%	0%	0%
Pattern 6: Bangladesh, Bolivia, Burkina Faso, Cambodia, Central African Republic, Democratic Republic of Congo, Guatemala, Haiti, Liberia, Mauritania, Nepal, Nigeria, Republic of Congo	30-100%	0%	0%	0%	0%	0%	0%

Patterns were defined as: Pattern 1: High population coverage, full provision of insulin and test strips, high proportion of direct costs covered, full availability; Pattern 2: High population coverage, full provision of insulin and test strips, high proportion of direct costs covered (with some co-payment), full availability; Pattern 3: Variable population coverage, mid-range provision of insulin with high proportion of direct costs covered, variable availability, limited provision of test strips with half or more of total direct costs covered, variable availability; Pattern 4: High population coverage, low to mid-range provision of insulin with high proportion of direct costs covered, good availability, no provision of test strips; Pattern 5: Variable population coverage, low to mid-range provision of insulin, with either a low proportion of direct costs covered or poor availability or both, no provision of test strips; Pattern 6: Medium to high population coverage, no provision of insulin, no provision of test strips.

Azerbaijan was the only unclassifiable country as its public health system covered a large share of the population, yet a wide range of services had to be paid for at full retail costs except for 50 test strips per year.

3.3.1 Visualisation of extent of UHC

Representative countries in each pattern were portrayed graphically to show differences in UHC for insulin and test strips (Figure 3).

3.4 *Coverage pattern and relationship to country income*

Figure 4 aggregates the coverage patterns of the 36 low-resourced countries (omitting Azerbaijan) and seven HICs, by World Bank income level.[19]

3.5 Other results

Erratic availability was commonly reported, especially in rural settings. Reported reasons included pharmacy stock outs, deriving from logistical problems, cumbersome regulatory procedures, and customs and taxes. Rwanda illustrates the problems for rural residents, with few rural pharmacies. When stock-outs occur, patients must travel long distances to obtain insulin from private pharmacies, with attendant travel, accommodation, and foregone work income costs.

Respondents from 34 of the less-resourced countries indicated the availability of Private Health Insurance (PHI) schemes but all described very low enrolment figures. Only five, in Ecuador, Jamaica, Mali, Sudan, and Togo, provided human insulin, with costs even more expensive than when accessed in the public systems, except in Mali and Togo where enrolees pay a percentage of the indicative public system cost. Blood glucose test strips were not provided in any PHIs.

Respondents from Azerbaijan and Nepal reported that their respective governments were piloting health insurance schemes, but commented that these schemes would only cover diabetes-related hospital admissions, not insulin or any other diabetes-related consumable.

4. Discussion

This paper presents a framework that can be used to document progress towards meeting the needs of people with T1DM at a time when governments are implementing UHC. We apply the framework to 37 low-resourced

countries, thereby illustrating the scale and nature of variation, with comparative data from seven high-income countries.

Much research on UHC focuses on financial coverage or access to a small number of specific interventions, such as immunisation or access to a skilled birth attendant. However, this provides only an extremely partial picture, and as noncommunicable diseases are increasingly prioritised in the international health agenda, it is essential to include systems that can monitor the extent to which health systems are responding to T1DM, ensuring that the necessary medicines and ancillary products are available and affordable for all.

We view this paper as proof of principle, rather than a set of definitive results which, ultimately, should be obtained from empirical studies. Ideally, these would involve a combination of objective measures, such as facility surveys to check price and availability, linked to data on income to assess affordability, complemented with user surveys to identify the barriers that people face in obtaining supplies.

Key Findings

Six broad patterns of provision were identified.

All seven high-income countries showed Patterns 1 and 2, with the public health systems providing complete coverage and availability, with a modest co-payment in the two Pattern 2 countries (Australia and Japan). As income level declined, coverage tended to decrease (Patterns 3-6). This is consistent with published data.[13]

Health systems in countries showing Patterns 3-5, many of which are low-income, supply varying degrees of insulin and test strips. This indicates that some countries have made steps towards achieving coverage of tools needed for the management of T1D. These countries provide potential examples for the 13 low and lower-middle income countries showing Pattern 6 where there was no government provision.

Clearly, countries must make difficult choices when resources are constrained. A decision not to provide analogue insulin can be justified, as the benefit of the substantially more expensive analogue over a “basal-bolus” human insulin regimen is very modest.[27,28] However, access to human short- and long-acting insulin is essential for instituting a basal-bolus regimen, which is a cornerstone of modern T1DM care.[29] This regimen cannot be delivered with pre-mixed insulin, which was the only insulin provided by two public systems.

While there are many problems with insulin supply, these are even greater with test strips, with only partial provision in five of the 37 less-resourced countries. This is consistent with an earlier LFAC study, which found that no public health systems in 37 LMICs and LICs provided test strips.[13] Self-monitoring of blood glucose (SMBG) is an essential tool in adequate management of T1DM. Insulin dosages can be adjusted to food and exercise patterns, dangerous extremes of blood glucose levels can be avoided entirely or more easily detected[30], and long-term complications reduced due to improved glycaemic control.[8,31] The lack of test strip provision is compounded by out-of-pocket costs as the purchase of strips can outweigh the costs of daily insulin in many countries.[6]

A possible contributor to this disparity is that although the WHO has a Essential Diagnostics List that details glucose testing, it is not listed for self-management, but only to diagnose and screen for diabetes, intermediate hyperglycemia and hypoglycaemia.[32]

The results demonstrate that, in addition to the three dimensions of coverage, availability must also be considered – entitlement to insulin is meaningless if it is not available. Recognising the limitations of our data, based on self-report, it is noteworthy that, of the 24 less-resourced health systems that provided insulin, 75% estimated <80% availability, with particular problems reported by many countries outside urban centres. These countries have not yet reached the voluntary global target of 80% availability of affordable essential medicines required to treat major noncommunicable diseases.[33]

This study focused on insulin and test strips, but comprehensive strengthening of national health systems is needed for adequate T1DM care, including skilled health professionals, diabetes education, and inpatient services. The WHO 'building blocks of the health system' framework is useful in this regard, showing the importance of leadership/governance, overall health system financing, the health workforce, information and research, and service delivery.[34]

Some less-resourced countries have created health insurance programs, but as other authors have noted, these face several challenges: cost recovery can be difficult, flat-rate premiums result in the most vulnerable and poor being unable to access the program, and non-mandatory membership undermines revenue generation and risk-pooling.[35] A full discussion of these issues is beyond this paper, however we note three indicative examples.

The NHIF in Tanzania, which provides insulin and test strips, is compulsory for employees and their families and it is also offered to other workers and youth. For government workers, yearly fees amount to 6% of an employee's annual salary per year (split by employee and employer)[17], with 17% of the population enrolled. The Mutuelles de Santé in Rwanda has means-tested fees. 75% of the population was enrolled in 2015[36], and human insulin was subsidised, with fair availability. Enrolled patients contributed a 10% co-payment plus prescription fees. However, there was no coverage for strips. In Ghana's NHIS, 40% of the population was enrolled in 2016 and end-users funded annual enrolment fees through social security contributions and premium payments[37], but insulin was frequently not available and strips were not covered.

In theory, private health insurance programs could potentially help people with T1DM who could afford the premiums, if those premiums were community rather than risk-related and if other barriers to recruitment were eliminated. However, the finding that these private schemes do not appear to cover outpatient medication costs, beyond those in a few countries that offer human insulin only, is of concern. The ongoing expense to someone with a chronic disease should be addressed.

Finally, the radar graphs/triangles compiled in this study can readily be used to document progress being made in coverage of those with other diseases.

Study limitations

This study has some obvious limitations. Firstly, the data were obtained from a single investigator in each country, and thus we were unable to compare national estimates on population, services, and costs. However, the country investigators were all experts responsible for organising care for young people with diabetes in their countries and thus were able to provide a broad assessment of national context. Their assessments were intended to cover the overall national, rather than just the region where the respondent was located, and were based on his or her self-

assessment and expert judgement, and at a single point in time. Additionally, indirect costs, including transportation or absenteeism, associated with accessing insulin or test strips were not taken into consideration. Finally, this survey only includes a sample of high-income countries and it excludes the USA. It, almost uniquely among high income countries does not provide universal coverage and its prices of insulin are very much higher than in comparable countries. Hence, it is widely considered an extreme outlier in international comparisons. Moreover, given the unique complexity of the US health system, with multiple payers and delivery schemes, it would be misleading to provide summary statistics.

The results of this study clearly cannot be expected to provide a definitive and comprehensive assessment of patterns of price and availability. However, we hope that the framework we propose could become the basis of a system to monitor progress in the ability to manage diabetes, and thereby contribute to UHC. The next steps should include development of an agreed methodology, such as that used in the WHO/Health Action International Project on Medicine Prices and Availability,[38] that could be applied regularly in a range of countries to provide empirical, accurate, and representative data to monitor progress. This should also include measures that capture the actual financial burden falling on people living with diabetes related to their income, also including the coping strategies that they and their family members engage in[39], and recognising the barriers they often face in obtaining employment. In this respect, and while not claiming the same ambition, we note how the 2000 World Health Report[40], on assessing health systems performance, also suffered from many data gaps but stimulated a major effort that has led to a vast improvement of the available information worldwide.

5. Conclusion

There is great variation in health system coverage of insulin and test strips in less-resourced countries. Provision is inadequate in all countries studied, and the situation is worse for test strips than for insulin. Until there is a system in place to monitor and ensure that both insulin and test strips are both provided to all who need them, by equitable health systems at affordable prices, Goal 3 of the Sustainable Development Goals cannot be realised for people with T1DM in less-resourced countries.

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