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National evidence on glucose-lowering medication use for diabetes from 62 low- and middle-income countries

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Given rising diabetes prevalence globally, access to diabetes treatments is gaining urgency. Yet, it remains unknown which glucose-lowering medication types people with diabetes across low- and middle-income countries (LMICs) use. In this cross-sectional analysis, we pooled nationally representative data of 223,283 adults aged ≥25 years in 62 LMICs from 2009 to 2019. We found that 51.9% [95%-CI: 49.6%, 54.2%] of 21,715 individuals with diabetes were undiagnosed. Among individuals with diagnosed diabetes, 18.6% [95%-CI: 14.5%, 23.4%] reported using no glucose-lowering medication, 57.3% [95%-CI: 53.1%, 61.4%] only used oral medication, 19.5% [95%-CI: 17.6%, 21.5%] used oral medication and insulin, and 4.7% [95%-CI: 3.9%, 5.6%] used insulin alone. In low-income countries, fewer individuals with diabetes were diagnosed and treated than in middle-income countries. Yet, among individuals who did get diagnosed, insulin use was two-thirds higher in low-income countries (38.9% [95%-CI: 31.6%, 46.7%]) compared to middle-income countries (23.2%; 95%-CI: 21.0%, 25.5%]). This finding could suggest a need for earlier diagnosis and treatment initiation. Our results can inform national and regional drug procurement efforts across LMICs.

Globally, the burden of diabetes is increasingly borne by low- and middle-income countries (LMICs), where around 80% of the 828 million adults living with diabetes mellitus reside[1,2]. Given extant care gaps[3], international guidelines by the World Health Organization (WHO) recommend, next to behavioral interventions, various glucose-lowering medications with demonstrated cost-effectiveness for managing diabetes and preventing complications, including in low-resource settings[4]. Yet, the availability and affordability of essential glucose-lowering medications, including insulin, is limited in many LMICs[5]. Although access to medicines has been recognized as a key barrier to delivering diabetes care[6], there is little empirical information about which glucose-lowering medication types individuals with diagnosed diabetes use.

Using cross-sectional, nationally representative data of adults aged ≥25 years from 62 LMICs, we show global and country-level patterns of glucose-lowering medication use for diabetes. This

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Table 1 | Characteristics of surveys and study populations, by geographical region

Region	Country	Survey year	Survey type	Country income group	Response rate	Sample size	Mean age, years (SD)	# of women (weighted %)	Diabetes prevalence
LAC	Chile	2009-10	Non-STEPS	Upper-MIC	85.0%	3826	47.6 (15.6)	2281 (50.5%)	10.1%
	Costa Rica	2010	STEPS	Upper-MIC	87.8%	2306	47.2 (12.4)	1680 (50.9%)	10.2%
	Ecuador	2018	STEPS	Upper-MIC	69.4%	3351	44.6 (12.1)	1967 (51.6%)	9.1%
	El Salvador	2014-2015	Non-STEPS	Lower-MIC	67.6%	3940	48.2 (16.7)	2467 (54.8%)	10.6%
	Guyana	2016	STEPS	Upper-MIC	77.0%	789	41.9 (5.6)	498 (52.9%)	20.0%
	Mexico	2018	Non-STEPS	Upper-MIC	90.0%	11,857	49.3 (28.6)	6,52 (58.5%)	18.3%
ECA	Azerbaijan	2017	STEPS	Upper-MIC	97.3%	2394	43.1 (10.0)	1427 (51.2%)	8.2%
	Belarus	2016	STEPS	Upper-MIC	87.1%	4423	45.9 (14.0)	2586 (52.4%)	5.2%
	Georgia	2016	STEPS	Lower-MIC	75.7%	2969	46.4 (11.6)	2148 (52.7%)	6.5%
	Kyrgyzstan	2013	STEPS	Lower-MIC	100.0%	2482	40.8 (9.6)	1567 (48.4%)	5.4%
	Moldova	2013	STEPS	Lower-MIC	83.5%	3341	43.8 (12.0)	2125 (50.2%)	7.0%
	Mongolia	2019	STEPS	Lower-MIC	97.4%	5436	41.6 (14.1)	3002 (50.5%)	9.9%
	Romania	2015-2016	Non-STEPS	Upper-MIC	69.1%	1775	51.5 (11.1)	931 (52.5%)	11.4%
	Tajikistan	2016	STEPS	Lower-MIC	94.0%	2171	36.3 (9.1)	1270 (43.6%)	5.5%
	Turkmenistan	2018	STEPS	Upper-MIC	93.8%	3304	41.2 (11.6)	1878 (48.2%)	6.9%
SEA	Afghanistan	2018	STEPS	LIC	–	2500	41.2 (10.0)	1130 (45.8%)	14.0%
	Bangladesh	2018	STEPS	Lower-MIC	83.3%	6010	41.8 (14.7)	3142 (52.3%)	9.0%
	Bhutan	2019	STEPS	Lower-MIC	96.9%	4709	41.1 (13.3)	2872 (43.3%)	3.6%
	Cambodia	2010	STEPS	LIC	96.3%	5026	40.5 (12.9)	3236 (50.8%)	2.4%
	China	2009	Non-STEPS	Upper-MIC	88.0%	8098	52.5 (20.8)	4313 (53.3%)	8.7%
	Indonesia	2014	Non-STEPS	Lower-MIC	90.5%	4868	43.7 (15.2)	2701 (51.8%)	8.0%
	Laos	2013	STEPS	Lower-MIC	99.2%	2083	42.4 (8.3)	1247 (58.4%)	5.7%
	Myanmar	2014	STEPS	Lower-MIC	94.0%	7754	41.8 (16.2)	5048 (49.2%)	6.4%
	Nepal	2019	STEPS	Lower-MIC	86.4%	4456	40.7 (13.9)	2835 (53.1%)	6.7%
	Sri Lanka	2014	STEPS	Lower-MIC	72.0%	3819	43.8 (12.9)	2350 (49.8%)	12.3%
	Vietnam	2015	STEPS	Lower-MIC	97.4%	2761	42.8 (10.6)	1580 (50.6%)	3.1%
SSA	Benin	2015	STEPS	LIC	98.6%	4038	39.0 (11.8)	2103 (53.7%)	6.6%
	Botswana	2014	STEPS	Upper-MIC	63.0%	2573	39.2 (10.0)	1773 (48.8%)	3.8%
	Burkina Faso	2013	STEPS	LIC	99.1%	3944	39.2 (11.5)	1998 (53.0%)	2.7%
	Comoros	2011	STEPS	LIC	96.5%	2298	41.7 (9.2)	1696 (73.8%)	4.3%
	Eritrea	2010	STEPS	LIC	97.0%	5360	43.6 (15.7)	3801 (80.5%)	3.7%
	Eswatini	2014	STEPS	Lower-MIC	76.0%	1863	40.5 (8.8)	1251 (55.9%)	6.6%
	Ethiopia	2015	STEPS	LIC	95.5%	6503	37.9 (15.7)	3713 (44.9%)	2.3%
	Kenya	2015	STEPS	Lower-MIC	93.0%	3324	39.1 (11.2)	1978 (50.4%)	2.4%
	Lesotho	2012	STEPS	Lower-MIC	80.0%	1968	38.1 (8.2)	1294 (49.4%)	2.8%
	Liberia	2011	STEPS	LIC	87.1%	1539	37.6 (6.6)	827 (53.7%)	13.1%
	Malawi	2009	STEPS	LIC	95.5%	2804	38.7 (9.8)	1936 (49.8%)	0.9%
	Mozambique	2014-2015	STEPS	LIC	98.4%	1562	40.6 (7.4)	931 (58.1%)	5.1%
	Rwanda	2012	STEPS	LIC	99.8%	5078	38.7 (12.6)	3160 (52.4%)	1.6%
	Seychelles	2013	Non-STEPS	Upper-MIC	73.0%	1240	42.6 (6.2)	709 (49.9%)	19.4%
	South Africa	2012	Non-STEPS	Upper-MIC	81.3%	2987	44.2 (13.3)	1955 (53.5%)	13.5%
	Sudan	2016	STEPS	Lower-MIC	95.0%	5311	40.0 (14.1)	3348 (45.9%)	8.3%
	Tanzania	2012	STEPS	LIC	94.7%	4573	39.0 (12.2)	2386 (49.9%)	2.8%
	Togo	2010	STEPS	LIC	91.0%	2548	38.9 (9.3)	1287 (51.5%)	3.3%
	Zambia	2017	STEPS	Lower-MIC	74.0%	2564	39.2 (9.4)	1566 (50.0%)	8.2%
	Zanzibar	2011	STEPS	LIC	91.0%	2173	38.8 (7.9)	1331 (50.9%)	3.6%

Table 1 (continued) | Characteristics of surveys and study populations, by geographical region

Region	Country	Survey year	Survey type	Country income group	Response rate	Sample size	Mean age, years (SD)	# of women (weighted %)	Diabetes prevalence
MENA	Algeria	2016	STEPS	Upper-MIC	93.8%	5183	42.0 (14.0)	2844 (48.6%)	11.6%
	Iran	2016	STEPS	Upper-MIC	98.4%	18,536	47.6 (34.0)	9859 (53.8%)	10.3%
	Iraq	2015	STEPS	Upper-MIC	98.8%	2145	45.4 (11.2)	1324 (51.3%)	23.4%
	Jordan	2019	STEPS	Upper-MIC	97.0%	2879	42.1 (10.7)	1874 (52.3%)	14.6%
	Lebanon	2017	STEPS	Upper-MIC	65.9%	1106	43.5 (6.4)	692 (52.3%)	13.3%
	Libya	2009	STEPS	Upper-MIC	73.0%	1771	37.4 (7.5)	789 (46.9%)	13.8%
	Morocco	2017	STEPS	Lower-MIC	89.0%	4207	46.1 (16.2)	2736 (50.9%)	13.6%
OCN	Fiji	2011	STEPS	Lower-MIC	80.0%	2424	41.9 (8.8)	1359 (49.4%)	13.6%
	Kiribati	2015	STEPS	Lower-MIC	55.0%	984	42.1 (6.1)	549 (55.0%)	20.2%
	Marshall Islands	2017	STEPS	Upper-MIC	92.3%	2252	42.8 (9.8)	1168 (51.9%)	31.8%
	Nauru	2015-2016	STEPS	Upper-MIC	74.5%	785	40.0 (5.4)	420 (51.1%)	20.6%
	Palau	2011-2013	STEPS	Upper-MIC	73.0%	1876	43.2 (7.7)	972 (46.3%)	20.0%
	Samoa	2013	STEPS	Lower-MIC	64.0%	1306	41.4 (6.7)	787 (48.0%)	24.6%
	Solomon Islands	2015	STEPS	Lower-MIC	58.4%	1440	41.5 (7.1)	782 (51.8%)	5.3%
	Tokelau	2014	STEPS	Upper-MIC	70.0%	425	40.8 (4.0)	222 (52.6%)	30.9%
	Tuvalu	2015	STEPS	Upper-MIC	76.0%	860	43.6 (6.1)	471 (46.0%)	12.8%
	Vanuatu	2011	STEPS	Lower-MIC	94.0%	4406	39.6 (12.1)	2165 (52.1%)	16.2%
	World (all data)	2009-2019	-	-	89.5%	223,283	42.2 (12.6)	131,189 (51.8%)	10.1%

The Afghanistan STEPS survey did not provide a response rate. Data on age and sex were missing for 9 (0.00%) and 2 (0.00%) participants, respectively. Proportions estimated using the sampling weights provided by each survey. *STEPS* Stepwise Approach to Non-Communicable Disease Risk Factor Surveillance, *LAC* Latin America and the Caribbean, *ECA* Eastern Europe and Central Asia, *SEA* South, East, and Southeast Asia, *SSA* Sub-Saharan Africa, *MENA* Middle East and Northern Africa, *OCN* Oceania.

evidence is crucial for understanding potential access disparities and informing future drug procurement efforts, aiming to improve diabetes care globally.

Results

Our final sample comprised 223,283 individuals in 13 low-income, 25 lower-middle-income, and 24 upper-middle-income countries across six world regions (Table 1). Out of the 62 countries, 54 (87.1%) used WHO Stepwise Approach to Non-Communicable Disease Risk Factor Surveillance (STEPS) surveys and 8 countries employed surveys with comparable sampling and measurement methodologies. Data were collected between 2009 and 2019 with a median response rate across surveys of 89.5% (IQR: 75.7%, 96.3%). Weighted diabetes prevalence based on glycemic markers was 10.1% (95% CI: 9.3%, 10.9%; $N = 21,715$).

Among the 48.1% (95% CI: 45.8%, 50.4%) of people with diabetes who were diagnosed, 81.4% reported using some form of glucose-lowering medication. Specifically, 57.3% (95% CI: 53.1%, 61.4%) only used oral medication, 19.5% (95% CI: 17.6%, 21.5%) used oral medication and insulin, and 4.7% (95% CI: 3.9%, 5.6%) only used insulin (Fig. 1). In aggregate, 76.8% of people with diagnosed diabetes used oral medication, and 24.1% used insulin, mostly in combination with oral medicines.

Medication use patterns and proportions diagnosed varied substantially across countries (Fig. 2 and Supplementary Table 6) and geographical regions (Supplementary Fig. 3). For example, in Latin America and the Caribbean, 68.7% (95% CI: 65.0%, 72.2%) of people with diagnosed diabetes used oral medication only, whereas in Oceania, this proportion was 47.1% (95% CI: 39.6%, 54.6%). In all countries except Rwanda and Libya, oral diabetes medication use was higher than insulin use.

In countries with higher income levels, larger proportions of people with diabetes were diagnosed and received treatment (Fig. 3). Among those diagnosed, the proportion using oral medication alone was significantly lower in low-income countries (44.5%; 95% CI: 37.9%, 51.4%) than in lower-middle- and upper-middle-income countries (58.1%; 95% CI: 53.6%, 62.5%). Conversely, low-income countries had a significantly higher proportion of individuals with diagnosed diabetes using insulin as either a single-drug or combination therapy (38.9%; 95% CI: 31.6%, 46.7%) compared to middle-income countries (23.2%; 95% CI: 21.0%, 25.5%). However, when including all individuals with diabetes (diagnosed or undiagnosed) in the denominator, insulin use did not significantly differ across country-income groups (10.9% versus 11.7%; $p = 0.627$; Supplementary Table 7), given that a smaller proportion of people with diabetes in low-income countries was diagnosed and treated.

Stratifying results by individual-level characteristics, we found that medication use patterns did not vary across participants' wealth quintiles (Supplementary Fig. 4) or sex (Supplementary Fig. 5). Individuals in older age groups were more likely to be diagnosed and treated, and more often used oral diabetes medicines only (Supplementary Fig. 6).

Overall, 49.1% (95% CI: 46.0%, 52.2%) of individuals using medication attained glycemic control. The prevalence of controlled diabetes did not significantly differ by type of glucose-lowering medication used (Supplementary Table 8). Considering behavioral treatments, 70.7% (95% CI: 66.4%, 74.7%) of diagnosed diabetes patients using no medication previously received advice on health behaviors (physical activity, weight loss, and/or diet), compared to 79.2% (95% CI: 76.7%, 81.5%) among individuals who did use medication (Supplementary Table 9).

In robustness checks, we found no substantial differences in medication use between surveys conducted before versus after 2015 (Supplementary Fig. 7). Our main findings were similar when weighting countries proportional to population size (Supplementary Fig. 8) instead of weighting countries equally.

Discussion

In nationally representative data from 62 LMICs, we found that four out of five people with diagnosed diabetes reported using glucose-lowering medication. Nearly one quarter of diagnosed individuals used insulin, mostly in combination with oral medicines. Medication use patterns varied substantially across countries and regions. Although fewer individuals with diabetes were diagnosed and treated in low-income countries, among those who did get diagnosed, insulin use was

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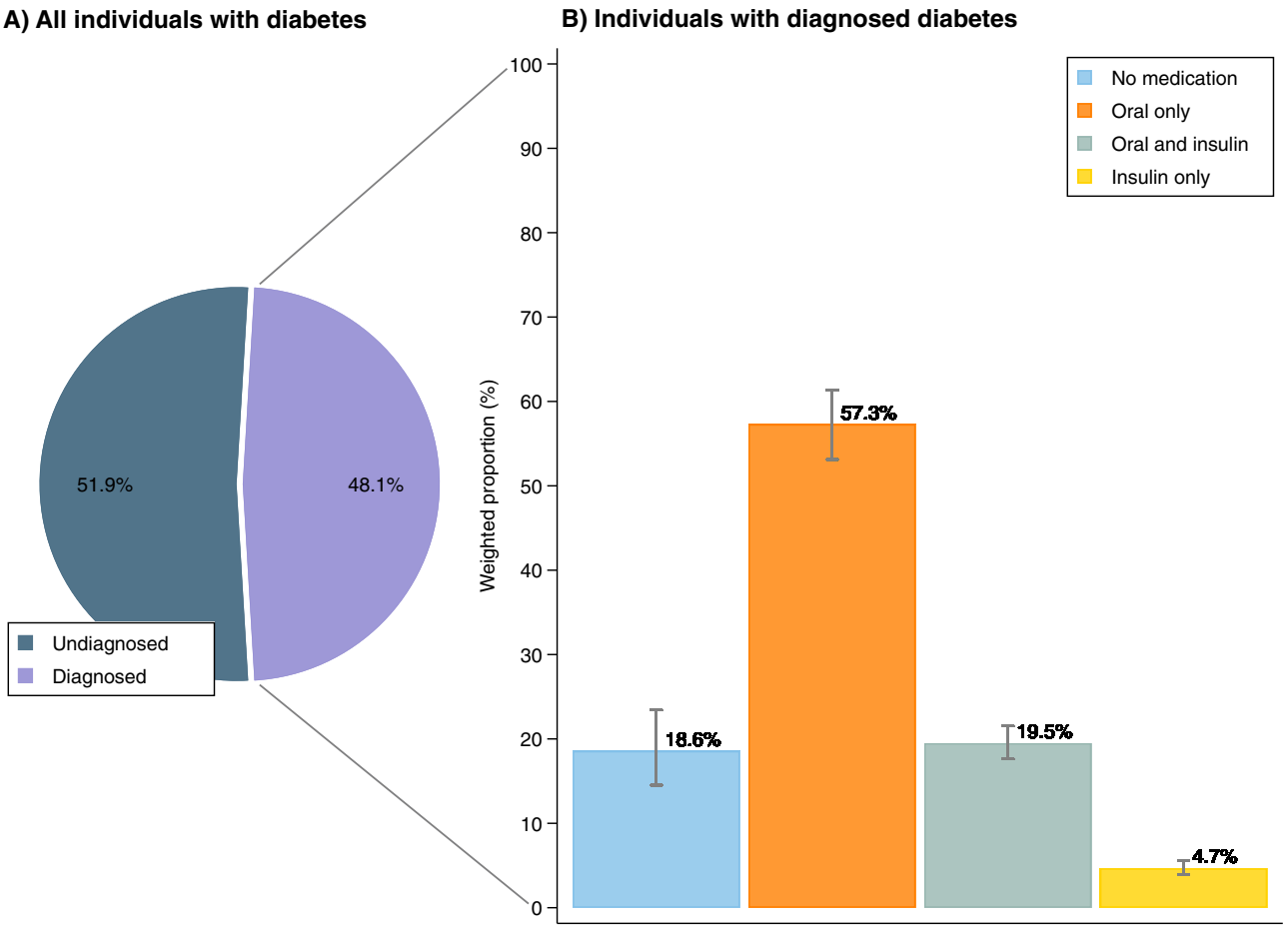

Fig. 1 | Glucose-lowering medication use for diabetes across 62 low- and middle-income countries. Proportion of all individuals (**A**) with diabetes who are diagnosed and (**B**) with diagnosed diabetes who use no medication, oral medication only, insulin only, or a combination of oral medication and insulin. Diabetes was defined as HbA1c ≥ 6.5%, fasting plasma glucose ≥7.0 mmol/L (≥ 126 mg/dl), random plasma glucose ≥11.1 mmol/L (≥ 200 mg/dl), or use of glucose-lowering medications. Diabetes diagnosis and medication use were self-reported. Estimated using re-scaled sampling weights, such that each country was weighted equally. Top edges of bars indicate weighted proportion estimates; error bars indicate 95%-confidence intervals. $N = 21,715$. Source data are provided as a Source Data file.

two-thirds higher compared to people with diagnosed diabetes in middle-income countries.

In many LMICs, access to various types of glucose-lowering medications is limited. Prior research employing pharmacy audits found that metformin is the most commonly available glucose-lowering drug across LMICs[5]. Insulin, in contrast, was available in less than half of audited pharmacies, ranging from 10.3% in low-income countries to 40.2% in upper-middle-income countries. Similarly, the affordability of glucose-lowering medications varied across drug classes and country-income groups. While glibenclamide was relatively affordable across LMICs, only one-third of households in low-income countries could afford insulin without incurring catastrophic health expenditure[5].

In countries with good availability of diabetes medications, where medication use is largely decoupled from patients' capacity to pay, such as Denmark, Sweden, Canada, Australia, or England, around 15–25% of type 2 diabetes patients used insulin, mostly in combination with oral medicines[7–9]. These findings are comparable to our results in middle-income countries. Yet, proportions of diabetes patients requiring oral medicines, insulin, or only behavioral interventions are likely dependent on contextual factors and population-specific pathophysiological predispositions[10].

Our findings are important for health systems and health policy. First, the patterns of glucose-lowering medication use can offer guidance for national and regional drug procurement efforts[11]. The finding that medication use varied across countries and country-income groups, but not by individual-level wealth, emphasizes the relevance of strategies for strengthening supply chains and increasing access to medicines at the national level[12].

Second, the combination of low proportions diagnosed and relatively high insulin use among those diagnosed in some LMICs might suggest the need for earlier detection and treatment initiation, especially if late-stage diagnosis of more severe diabetes is driving higher need for insulin[13]. Moreover, heterogeneity in insulin use across regions and country-income groups could point to different distributions of type 2 diabetes phenotypes, particularly those marked by deficient insulin secretion[10].

Third, in low-income countries, relatively high insulin use among people with diagnosed diabetes could also arise from limited access to and/or under-prescription of insulin-sparing medications. For instance, in various Sub-Saharan African countries, glibenclamide is substantially cheaper than metformin[12], but can result in earlier need for insulin therapies[14]. In our study, 11 out of 13 low-income countries were in Sub-Saharan Africa. Expanding access to newer diabetes medicines, such as SGLT-2 inhibitors or GLP-1 receptor agonists, might further spare insulin use, though current prices pose a barrier[15].

To advance our understanding of global variation in glucose-lowering medication use, longitudinal evidence is needed that maps disease trajectories of diabetes patients across the care continuum, including at which disease stages patients enter care, get diagnosed,

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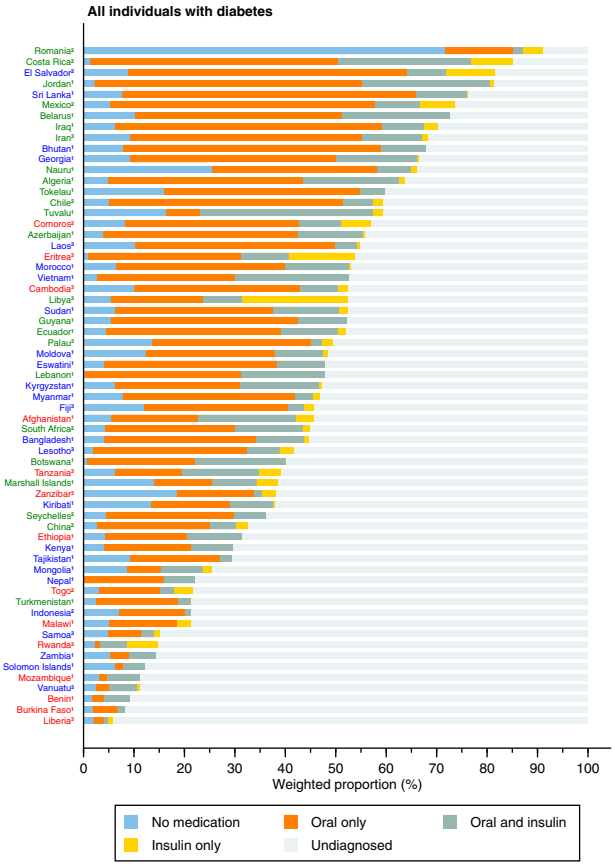

Fig. 2 | Country-level medication use patterns. Proportion of all individuals with diabetes ($N = 21,715$) by country who use no medication, oral medication only, insulin only, a combination of oral medication and insulin, or are undiagnosed. Country names are colored according to World Bank country-income group (red = low-income country; blue = lower-middle-income country; green = upper-middle-income country). Superscript numbers indicate differences in survey questionnaires: 1) surveys asked for diabetes medication use *before* asking for insulin use; 2) surveys included a multiple-choice question on different diabetes treatment options and/or explicitly specified *oral* diabetes medication; 3) surveys asked for diabetes medication use *after* asking for insulin use. Estimated using the sampling weights provided by each survey. Source data are provided in Supplementary Table 6.

initiate treatment, and escalate treatment, and the impact each step has on diabetes control rates. Such evidence needs to integrate data on diabetes phenotypes, as well as information on treatment protocols in different countries and corresponding prescribing behavior of providers.

Our study has several limitations. First, given limited surveillance and data infrastructure for diabetes in many LMICs, data from different countries were collected at different time points and some surveys were more than ten years old at the time of analysis. However, we observed no substantial differences in medication use between less and more recent surveys. Second, surveys did not distinguish between diabetes types and we did not have data on specific medication classes that participants used. Therefore, we could not infer the appropriateness of treatment regimens at the individual level. The prevalence of type 1 diabetes might vary across countries and influence overall insulin use, though less than 5% of diabetes cases globally are type 1[16]. Third, medication use and diagnosis were self-reported, which may have led to modest misclassification, for example due to limited knowledge among patients. However, the validity of medication self-reports for diabetes is generally found to be high[17]. Fourth, questions on diabetes medication and insulin use were asked in a different order and with slightly different wording across surveys (Supplementary Table 5), which for instance may lead to underestimation of insulin use as a single-drug vis-à-vis combination therapy. Fifth, some smaller surveys included relatively few or no individuals with diagnosed diabetes using insulin alone, increasing the chance of random error, which, where possible, we quantify using 95%-CIs (Supplementary Table 6).

In conclusion, half of people living with diabetes across LMICs are undiagnosed. Of those with diagnosed diabetes, 81% report using glucose-lowering medication, though patterns of medication use vary substantially by country, geographical region, and country-income group. Relatively high insulin use in low-income countries, where fewer people with diabetes are diagnosed, could suggest a need for earlier diagnosis and treatment initiation. Future data on diabetes phenotypes and prescribing patterns are needed. Tailoring the management of diabetes to different contexts will contribute to improving health system performance for diabetes across LMICs.

Methods

Ethical approval for each survey was granted by the respective country's ethics review committee prior to data collection. The extant study and complete dataset were deemed non-human subjects research by the institutional review boards of the Harvard T.H. Chan School of Public Health (protocol IRB16-1915) and Emory University, respectively. Respondents gave written informed consent and received no compensation.

In this cross-sectional study, we performed a pooled analysis of individual participant, nationally representative data of 62 LMICs from the Global Health and Population Project on Access to Care for Cardiometabolic Diseases (HPACC). We systematically searched national surveys with diabetes biomarkers (Supplementary Methods and Supplementary Fig. 1). The most common source for identifying and accessing surveys was the WHO data repository[18]. Several additional surveys that are not yet publicly available were obtained through formal requests to survey teams.

In each country, we selected the most recent survey meeting our inclusion criteria. For the present study, we included surveys that (1) were conducted in 2009 or later; (2) were done in a low-income, lower-middle-income, or upper-middle-income country, according to World Bank country-income group classification in the year of data collection[19]; (3) contained participant-level data; (4) were nationally representative of the adult population; (5) had a response rate of 50% or higher; and (6) contained data on diabetes biomarkers (either an HbA1c or blood glucose measurement). Prior to collation, we performed detailed data quality assessments and harmonized data on key variables[20].

To obtain nationally representative samples, most included surveys used a multi-stage cluster random sampling approach[20]. Survey-specific sampling strategies are detailed in Supplementary Table 1.

Our study population included all non-pregnant individuals 25 years and older with complete data on diabetes biomarkers and medication use (Supplementary Fig. 2). This age threshold corresponds to the minimum age for eligibility in most included surveys.

We ascertained diabetes status using the following criteria: (1) HbA1c ≥ 6.5%; (2) fasting plasma glucose ≥7.0 mmol/L (≥126 mg/dl); (3) random plasma glucose ≥11.1 mmol/L (≥200 mg/dl); or (4) self-reported use of prescribed glucose-lowering medication. Capillary glucose measurements were converted to plasma equivalents[21]. Details on glucose measurement for each survey are provided in Supplementary Table 2. While we cannot distinguish between diabetes types, type 2 diabetes accounts for 96% of all diabetes cases among adults of any age globally[16]. Despite some variation, in 90% of countries more than 90% of diabetes cases are type 2 rather than type 1. These proportions are likely higher in adults aged ≥25 years.

Diabetes diagnosis status was based on self-report; all participants were asked if a health professional ever diagnosed them with diabetes.

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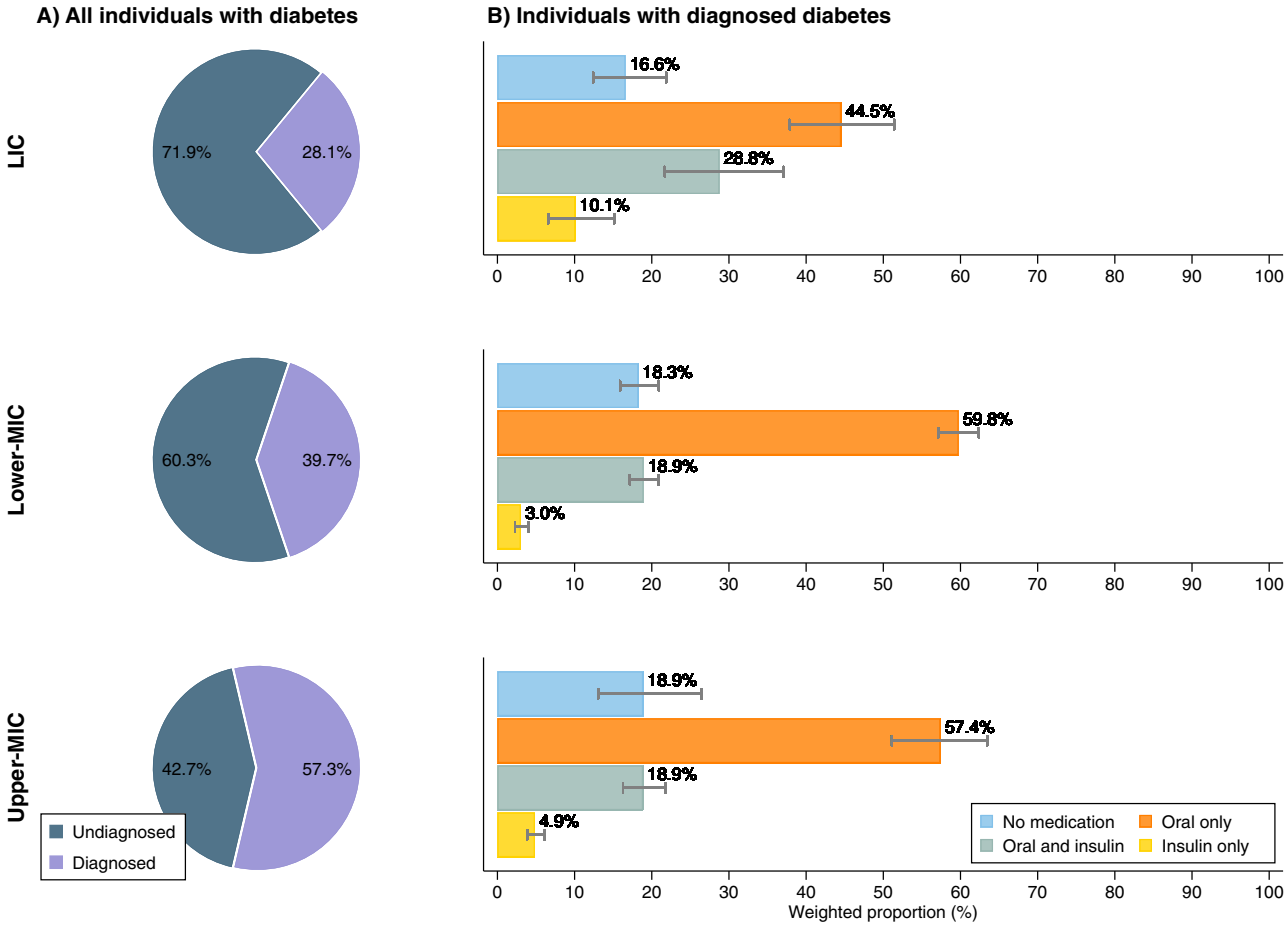

Fig. 3 | Medication use patterns stratified by country-income group. Proportion of all individuals (**A**) with diabetes who are diagnosed and (**B**) with diagnosed diabetes across countries who use no medication, oral medication only, insulin only, or a combination of oral medication and insulin, by World Bank country-income group (low-income countries [*N* = 2104]; lower-middle-income countries [*N* = 8244], upper-middle-income countries [*N* = 11,367]) at time of survey data collection. Estimated using re-scaled sampling weights, such that each country was weighted equally. *LIC* low-income countries, *MIC* middle-income countries. Right edges of bars indicate weighted proportion estimates; error bars indicate 95%-confidence intervals. Source data are provided as a Source Data file.

Individuals who reported no previous diabetes diagnosis but had elevated biomarkers were considered as having undiagnosed diabetes. Current medication use was determined through two separate questions on insulin use and the use of any (oral) glucose-lowering medication, respectively (Supplementary Table 3).

Among individuals with diagnosed diabetes, we estimated mutually exclusive proportions of individuals who (1) did not use glucose-lowering medications, or used (2) only oral medication, (3) only insulin, or (4) a combination of insulin and oral medication. We estimated these proportions at the global-, regional-, country-, and World Bank country-income group-level[22]. We also compared medication use by survey year (2009 to 2014 versus 2015 to 2019). Moreover, we stratified our results by individual-level characteristics (Supplementary Table 4), including ten-year age group, self-reported sex, and – in a sub-sample of 51 countries with data on household wealth – wealth quintiles. The construction and harmonization of household wealth quintiles is described in Supplementary Table 5 and further detailed elsewhere[20,23].

In an exploratory analysis, we estimated the prevalence of controlled diabetes (defined as HbA1c < 7.0% or FBG < 8.6 mmol/L)[24] among individuals using different types of glucose-lowering medication. Lastly, we estimated proportions of diabetes patients who previously received advice on health behaviors (physical activity, weight loss, and/or diet).

In all statistical analyses, we used sampling weights provided by surveys to adjust for nonresponse, selection probabilities, and systematic differences between sample populations and target populations. In all pooled analyses, we rescaled sampling weights, such that each country was weighted equally[22]. In a robustness check, we re-scaled sampling weights in proportion to population size of the respective country[20]. We used Stata version 15.1 for all analyses.

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Data availability

Findings reported in this study are based on the pooled, harmonized, de-identified, participant-level Global Health and Population Project on Access to Care for Cardiometabolic Diseases (HPACC) dataset. The dataset and accompanying data dictionary were created through a partnership between Harvard University, University of Göttingen, and Heidelberg University in collaboration with all in-country survey teams. Researchers can request access to the dataset for non-commercial purposes by contacting the HPACC team at hpacc@uni-heidelberg.de, allowing two weeks for responses. As further detailed on the HPACC website (https://www.hpaccproject.org/contact-us), data access can be granted after submission of a brief proposal via the HPACC Dataverse

(https://dataverse.harvard.edu/dataverse/hpacc) to ensure compliance with ethical standards. A simulated dataset for use with the replication code is available on GitHub (https://github.com/fxteufel/HPACC_diab_meds/)[25]. Source data are provided with this paper.

Code availability

Replication code is available on GitHub (https://github.com/fxteufel/HPACC_diab_meds/)[25].

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Author contributions

F.T., C.B., J.M., and M.A. conceived the study. F.T. performed the data analysis under supervision of C.B. and with support from M.M. and M.T. F.T. and C.B. wrote the initial draft of the paper, with input from J.M., M.A., M.M., M.T., D.F., A.D., J.D., P.R., and S.V. G.A., K.A., S.A., P.B., M.D., F.F., C.H., Ab.S., An.S., D.L., M.G., J.J., K.K., N.L., S.M., K.M., L.S., T.B., P.G. provided further critical input on the manuscript. F.T. and C.B. have accessed and verified the data. All co-authors read and reviewed the final paper and agreed with the decision to submit the paper for publication.

Competing interests

The authors declare no competing interests.

Additional information

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