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Cost of Metabolic Dysfunction-Associated Steatotic Liver Disease Screening Among All People Living With Diabetes in Six Countries

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ABSTRACT

Background and Aims: Metabolic dysfunction-associated steatotic liver disease (MASLD) and its progressive form, metabolic dysfunction-associated steatohepatitis (MASH), are highly prevalent among people living with type 2 diabetes, with estimated rates of 65.4% and 31.6%, respectively, globally. This study aimed to estimate the direct healthcare costs of two MASLD and MASH screening strategies among all people living with diabetes in Brazil, Germany, Japan, the Kingdom of Saudi Arabia (KSA), Spain and the United States (US), from 2026 to 2030.

Methods: Strategy 1 consisted of a one-time universal screening of all adults living with diabetes. Strategy 2 involved biennial retesting of individuals who initially tested negative. The Fibrosis-4 (FIB-4) index was used as the first line test, followed by the Enhanced Liver Fibrosis (ELF) test or vibration-controlled transient elastography (VCTE) for confirmatory assessment. Implementation costs were estimated based on the country-specific prevalence of diabetes and included positive price variations that were aligned to monetary policy targets.

Results: Over 5 years, the estimated costs of Strategy 1 ranged from R\$0.7–1.3 billion for Brazil, €346–617 million for Germany, ¥80–172 billion for Japan, SAR 3.7–6.0 billion for the KSA, €591–949 million for Spain and \$2.7–15.2 billion for the US. Strategy 2 resulted in higher costs, ranging from R\$1.2–2.0 billion for Brazil, €528–940 million for Germany, ¥121–262 billion for Japan, SAR 5.7–9.2 billion for the KSA, €0.9–1.4 billion for Spain and \$4.1–23 billion for the US.

Conclusions: This study provides valuable guidance for policymakers and healthcare managers to integrate liver fibrosis screening strategies for people living with diabetes into national health budgets.

Abbreviations: \$, United States dollar; ¥, Japanese yen; €, euro; ADA, American Diabetes Association; ALT, alanine transaminase; AST, aspartate aminotransferase; CPG, clinical practice guideline; CVD, cardiovascular disease; DSA, deterministic sensitivity analysis; ELF, Enhanced Liver Fibrosis; EMA, European Medicines Agency; US FDA, US Food and Drug Administration; FIB-4, Fibrosis-4; GBD, Global Burden of Disease; HCC, hepatocellular carcinoma; I\$, international dollar; IDF, International Diabetes Federation; KSA, Kingdom of Saudi Arabia; LTFU, lost to follow-up; MASH, metabolic dysfunction-associated steatohepatitis; MASLD, metabolic dysfunction-associated steatotic liver disease; MoC, model of care; NAFLD, non-alcoholic fatty liver disease; NASH, non-alcoholic steatohepatitis; NCD, non-communicable disease; R\$, Brazilian real; SAR, Saudi riyal; SDG, Sustainable Development Goal; T1D, type 1 diabetes; T2D, type 2 diabetes; UN, United Nations; US, United States; VCTE, vibration-controlled transient elastography; WHO, World Health Organization.

For affiliations refer to page 14.

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Summary

- Screening for metabolic dysfunction-associated steatotic liver disease (MASLD) and its progressive form, metabolic dysfunction-associated steatohepatitis (MASH), among people living with diabetes aligns with the World Health Organization's quick buys.
- In this first-ever comparison of MASLD and MASH screening costs, in six countries, a novel approach was taken by incorporating the costs of performing such screening among all individuals living with diabetes.
- Estimating the cost of screening for diseases can guide priority setting and resource allocation in national decision-making.

1 | Introduction

The prevalence of diabetes among people aged 20–79 years is estimated to be 11.1% globally and is expected to rise in the coming years, with approximately half of those living with the condition remaining unaware of their diagnosis [1]. Diabetes is closely associated with metabolic dysfunction-associated steatotic liver disease (MASLD) and its advanced form, metabolic dysfunction-associated steatohepatitis (MASH), formerly known as non-alcoholic fatty liver disease (NAFLD) and non-alcoholic steatohepatitis (NASH), respectively [2, 3]. Among individuals living with type 2 diabetes (T2D) [4] the prevalence of MASLD and MASH has been estimated at 65.4% (95% confidence interval [CI]: 61.8–68.2%) and 31.6% (95% CI: 17.1–50.7%), respectively. Meanwhile, the prevalence of MASLD is approximately 22.2% (95% CI: 15.6–30.7%) among those living with type 1 diabetes (T1D) [3, 5].

People living with diabetes and MASLD are at an increased risk of developing advanced liver fibrosis and progressing to severe liver outcomes, such as decompensated cirrhosis or hepatocellular carcinoma (HCC) [2]. The progression of MASLD is influenced by cardiometabolic risk factors such as insulin resistance and obesity, which accelerate fibrosis progression [6, 7]. Advanced liver fibrosis (stage 3 or higher) is an important predictor for liver-related and all-cause mortality [8–11]. Additionally, cardiovascular disease (CVD) is the leading cause of death among people living with MASH with fibrosis, particularly those with coexisting T2D [12, 13]. The complex interplay between cardiometabolic abnormalities and MASLD highlights the need for a comprehensive management approach with multidisciplinary care across different specialties. Several models of care (MoCs) have demonstrated that multidisciplinary care improves hepatic and extrahepatic outcomes in people living with MASLD and MASH [14–16].

MASLD has emerged as a public health threat, contributing to high direct and indirect healthcare costs and high rates of health service utilisation [17–19]; it is also one of the leading causes for liver transplantation [20]. Several studies have shown that screening individuals for MASLD is cost-effective, enabling earlier detection and timely and effective management to prevent or halt disease progression [21, 22]. As a result, many clinical practice guidelines (CPGs) recommend routine MASLD screening

among individuals living with T2D using non-invasive testing algorithms such as a two-tiered approach, with initial risk stratification via the Fibrosis-4 (FIB-4) index, followed by the Enhanced Liver Fibrosis (ELF) test or vibration-controlled transient elastography (VCTE) if FIB-4 results are high [23–25]. Such screening strategies, alongside the use of multidisciplinary MoCs, could not only improve health outcomes but also reduce the costs associated with diagnosing MASLD at advanced stages [26]. Additionally, the 2025 American Diabetes Association (ADA) Consensus Report on MASLD extended screening recommendations to individuals living with pre-diabetes [27].

CPGs and systematic reviews have emphasised the potential benefits of implementing screening strategies as a form of secondary prevention, aiming to effectively manage MASLD in its early stages through lifestyle-based interventions [28] or emerging pharmacotherapies. The latter includes resmetirum, which was approved by the US Food and Drug Administration (FDA) in March 2024 and in August 2025 by the European Medicines Agency (EMA) [26, 29–31]. Because MASLD-related liver fibrosis often progresses slowly, there is an opportunity to identify and treat people living with this condition before the onset of cirrhosis or HCC [32].

Lessons can also be drawn from the success of population-level screening for other conditions. For example, colorectal [33] and cervical cancer screening programmes have reduced disease-specific mortality, while risk-based approaches—such as lung cancer screening [34] or cardiovascular risk assessment—have guided early intervention and improved health outcomes in targeted populations [33].

2 | Aim

This study aimed to estimate the direct healthcare costs of two screening strategies for MASLD and MASH, among all people living with diabetes in Brazil, Germany, Japan, the Kingdom of Saudi Arabia (KSA), Spain and the United States, from 2026 to 2030. Strategy 1 consisted of one-time screening of all people living with diabetes. Strategy 2 involved biennial retesting of all people who initially tested negative.

3 | Methods

3.1 | Study Type and Population

A cost analysis was undertaken to estimate the direct healthcare costs of two screening strategies for MASLD and MASH among all individuals living with T1D and T2D in Brazil, Germany, Japan, the KSA, Spain and the US from 2026 to 2030, from a health system perspective. These countries were selected based on their health system and diabetes prevalence differences, as well as to contribute to the geographic diversity of the analysis. The 2026 to 2030 timespan was selected to align with the new World Health Organization (WHO) concept of 'quick buys', which is defined as interventions likely to show measurable effects within 5 years, consistent with the average electoral cycle in many countries [35]. It also aligns with the target completion date of the United Nations' Sustainable Development Goals (UN

SDGs), with the SDGs set out in Target 3.4 (i.e., ‘By 2030, reduce by one third premature mortality from non-communicable diseases [NCDs] through prevention and treatment and promote mental health and well-being’) being particularly relevant [36]. Screening and diabetes population estimates were derived from published recommendations and prevalence data, respectively [1, 23, 27, 37].

3.2 | Screening Strategies

3.2.1 | Strategy 1: Once-Only Screening (Without Retesting)

This strategy used the projected 2030 prevalence for T1D and T2D, derived from the Global Burden of Disease (GBD) study and the International Diabetes Federation (IDF) [1, 38], as the total population to be screened during the 2026 to 2030 period. This projected number of people was distributed uniformly within the 5-year period, meaning that 20% of the projected population living with T1D and T2D for 2030 was screened each year. This strategy involved screening everyone once and did not involve retesting (Figure 1).

3.2.2 | Strategy 2: Biennial Screening (With Retesting Every 2 Years)

Strategy 2 built upon Strategy 1 by incorporating biennial retesting of individuals who tested negative or were lost to follow-up (LTFU). For 2026 and 2027, the number of individuals screened

matched Strategy 1. However, those with a negative FIB-4, ELF, or VCTE result, and those LTFU in years 2026, 2027 and 2028, were retested in 2028, 2029 and 2030, respectively. Retesting beyond 2030 was not included. Consequently, the total number of screenings in Strategy 2 exceeded the projected T1D and T2D prevalence for 2030 (Figure 2).

For both strategies, it was assumed that 100% of the population scheduled to be screened underwent FIB-4 testing and, of these, 40% were expected to have results above the low-risk cut-off threshold and therefore proceeded to second-line testing with either ELF or VCTE. In Brazil, the ELF test was incorporated into this model from 2028 onward, acknowledging its current unavailability in the country and the potential for its introduction in the near future. It was also assumed that 85% of those who underwent ELF or VCTE tested positive and that 10% were LTFU. Country-specific proportions of ELF or VCTE use were applied to allocate costs accordingly (Table S1).

Costs were estimated on an annual basis without discounting, as all projected costs were expected to be evenly distributed across the 5-year period. Moreover, positive price variations that were aligned with monetary policy targets were incorporated. Results are reported in local currencies and international dollars (\$) for the year 2023.

3.3 | Deterministic Sensitivity Analysis

To account for uncertainty, a deterministic sensitivity analysis (DSA) was performed using a low-cost scenario (baseline –20%),

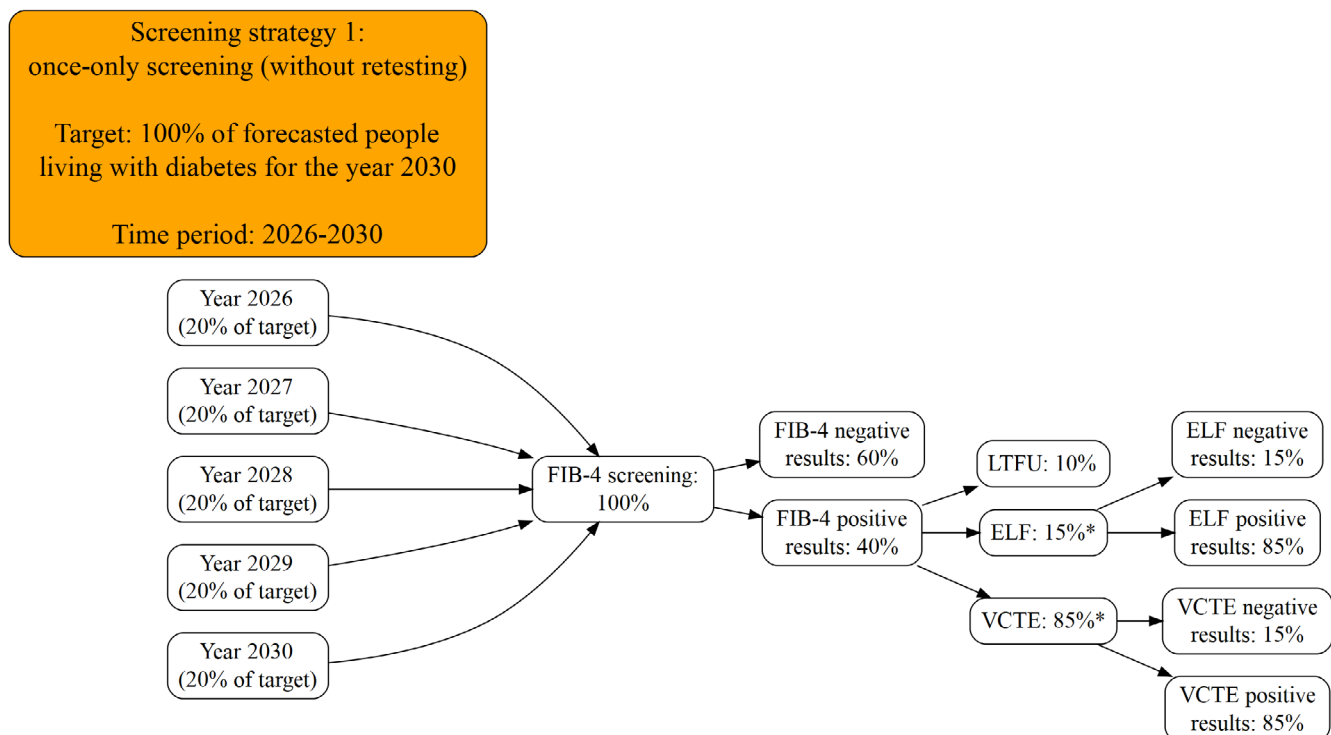


FIGURE 1 | MASLD and MASH screening strategy 1. ELF, Enhanced Liver Fibrosis; FIB-4, Fibrosis-4; LTFU, lost to follow-up; MASH, metabolic dysfunction-associated steatohepatitis; MASLD, metabolic dysfunction-associated steatotic liver disease; VCTE, vibration-controlled transient elastography. FIB-4 positive results are defined as ≥ 1.3 in individuals ≤ 65 years old and ≥ 2.0 in individuals > 65 years old; ELF positive results are defined as ≥ 9.8 . *Of the 90% that were not LTFU: VCTE positive results are defined as ≥ 8 kPa.

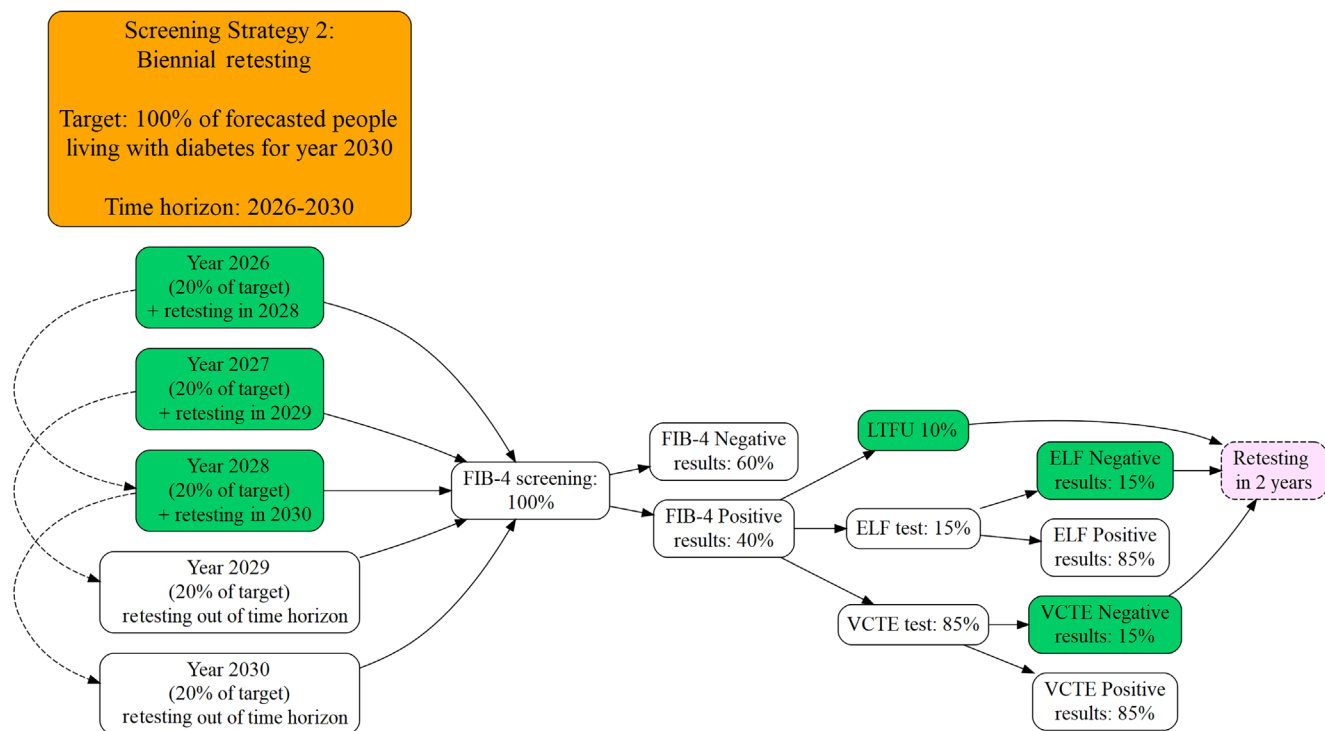


FIGURE 2 | MASLD and MASH screening strategy 2. ELF, Enhanced Liver Fibrosis; FIB-4, Fibrosis-4; LTFU, lost to follow-up; MASH, metabolic dysfunction-associated steatohepatitis; metabolic dysfunction-associated steatotic liver disease; VCTE, vibration-controlled transient elastography. FIB-4 positive results are defined as ≥ 1.3 in individuals ≤ 65 years old and ≥ 2.0 in individuals > 65 years old; ELF positive results are defined as ≥ 9.8 . *Of the 90% that were not LTFU: VCTE positive results are defined as ≥ 8 kPa.

a high-cost scenario (baseline +20%) and LTFU levels of 10% (baseline) and 20%. Due to greater uncertainty around cost estimates for the US, an additional high-cost scenario of baseline +200% was included for that country.

3.4 | Screening Pathway and Screening/Diagnosis Thresholds

A two-tiered screening approach, with FIB-4 testing followed by ELF or VCTE as second-line tests, was modelled. This approach was assumed to be implemented within the existing standards of care via which each country manages individuals living with diabetes, including their routine tests and follow-up visits. The screening pathway was assumed to start within the existing standard of care in which individuals living with diabetes are routinely managed and followed up in primary care. Primary care was considered the most appropriate entry point for screening, as it allows for early identification and referral. While specialists may become involved, this model aligns with evidence supporting a multidisciplinary approach to the management of patients at risk of having MASLD.

In the initial phase of screening, the FIB-4 was used as the first-line test for risk stratification for those with an intermediate-high risk of having MASLD, with a cut-off value of ≥ 1.3 for people aged ≤ 65 years and ≥ 2.0 for people aged > 65 years, indicating the need for referral to a liver specialist. Anyone with a FIB-4 above the cut-off would undergo second-line screening via ELF or VCTE, with cut-off values of ≥ 9.8 or ≥ 8.0 kPa,

respectively (Figure 3) [39]. In the model, it was assumed that 40% of those screened via FIB-4 would test positive and proceed with second-line testing, and that 85% of those undergoing ELF or VCTE would test positive [40–42].

3.5 | Input Description

Model inputs included the projected T1D and T2D prevalence for each country, direct cost inputs and national inflation targets (Table S2) and screening test positivity rates. LTFU rates were sourced from the literature but showed high variation. The proportion of second-line testing conducted using ELF versus VCTE for each country was obtained from the literature and expert opinion. All inputs were validated by experts from each country.

3.6 | Prevalence

T1D and T2D prevalence data were sourced from the GBD study 2021 or IDF Diabetes Atlas, 11th edition. GBD provided prevalence estimates for the years 2017–2021, which were used to generate linear trend projections for 2026 to 2030 (inclusive). IDF provided data for 2021, 2024 and 2030, which were also used to construct linear trend projections for 2026 to 2030 (inclusive) [1, 38].

GBD reported prevalence in absolute numbers, while IDF reported it in thousands. IDF values were therefore multiplied by 1000 to obtain absolute numbers.

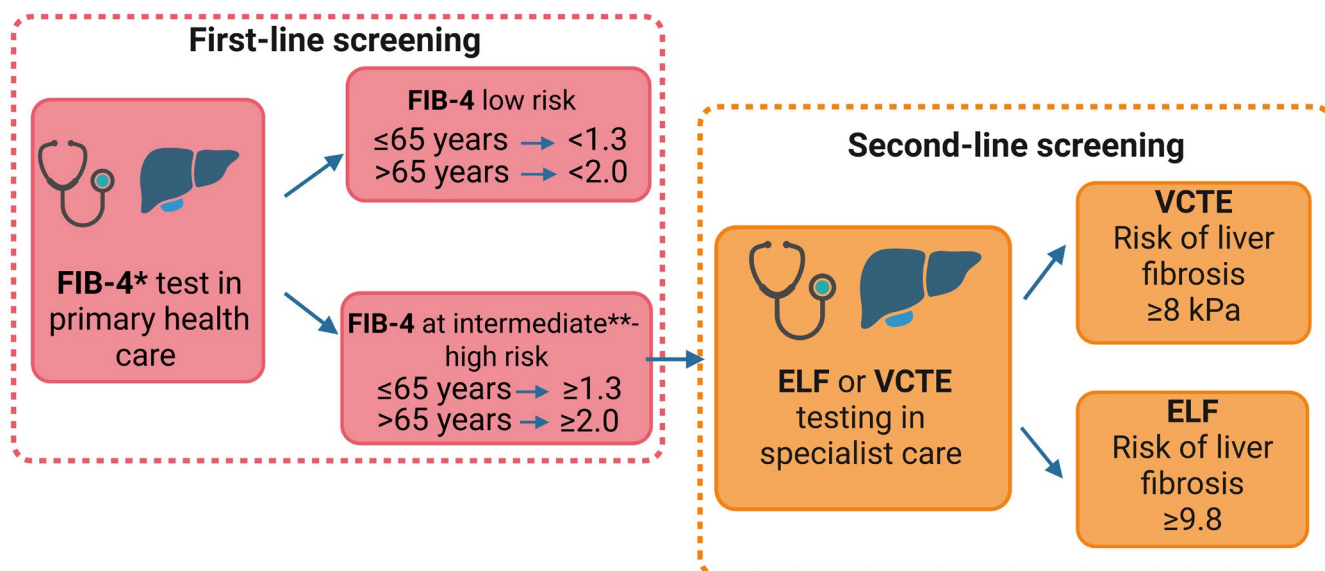


FIGURE 3 | Proposed two-tiered MASLD and MASH screening strategy among people living with diabetes and the risk stratification and diagnosis thresholds. ELF, Enhanced Liver Fibrosis; FIB-4, Fibrosis-4; MASH, metabolic dysfunction-associated steatohepatitis; MASLD, metabolic dysfunction-associated steatotic liver disease; VCTE, vibration-controlled transient elastography. *The FIB-4 index has a lower sensitivity among people < 35 years and a lower specificity the higher the age, particularly among those > 65 years, leading to potential false positives. Some studies suggest adjusting the threshold to 2.0 for people > 65 years, but these adjustments are not universally agreed upon. **The intermediate FIB-4 range is 1.3–2.67 in the general population (≤ 65 years); in older people (> 65 years) the lower cut-off is often 2.0, and in older adults and T2D accuracy is reduced.

IDF reported combined T1D and T2D data for the 20–79-year-old age group. GBD reported T1D and T2D using the categorical age groups < 20, < 70, 70–74 and 75–79; these were aggregated into one 20–79-year-old group for comparability. Methodological details for both data sources have been described elsewhere [1, 38].

3.7 | Cost Data

Direct cost data were sourced from country-specific fee schedules or relevant literature and validated by an expert panel. For FIB-4, costs included the laboratory sample collection and analysis for platelet count, aspartate aminotransferase (AST) and alanine transaminase (ALT). ELF testing costs were available for all countries but Brazil, where US costs were used as a proxy. VCTE costs were available for all countries. The cost of a physician visit was also included. For all countries, except the KSA, annual cost inflation was applied according to each country's monetary authority target rate. Since the KSA does not publish a specific inflation target, and the Saudi riyal (SAR) is pegged to the US dollar (\$), the US target inflation rate was applied (Table S2).

3.8 | Role of the Funding Source

This study was funded by Boehringer Ingelheim, Echosens and Novo Nordisk. The funders had no role in the study design, the data collection, analysis or interpretation or writing of the manuscript.

4 | Results

We computed two sets of results, using GBD and IDF prevalence estimates, presented jointly in Tables 1–3. The estimated

diabetes prevalence showed an upward trend in all cases except for Japan, where IDF data-based projections indicated a slight downward trend. For Brazil, the KSA and Spain, GBD-based prevalence estimates were lower than those from IDF, whereas the opposite pattern was observed for Germany, Japan and the United States (Table 1).

4.1 | Direct Healthcare Costs for Strategy 1: Once-Only Screening

The total costs for Strategy 1 (once-only screening), based on GBD and IDF estimates respectively and assuming a 10% LTFU, were as follows: in Brazil, R\$922 million (Brazilian reais) (range: R\$738–1107 million; people screened: 16.9 million in tier 1 and 6.1 million in tier 2) and R\$1.045 billion (range: R\$0.8–1.3 billion; people screened: 19.2 million in tier 1 and 6.9 million in tier 2); in Germany, €514 million (euros) (range: €411–617 million; people screened: 7.8 million in tier 1 and 2.8 million in tier 2) and €433 million (range: €346–519 million; people screened: 6.6 million in tier 1 and 2.4 million in tier 2); in Japan, ¥143 billion (Japanese yen) (range: ¥115–172 billion; people screened: 15 million in tier 1 and 5.5 million in tier 2) and ¥100 billion (range: ¥80–119 billion; people screened: 10.5 million in tier 1 and 3.8 million in tier 2); in the KSA, SAR 4.6 billion (range: SAR 3.7–5.6 billion; people screened: 5.3 million in tier 1 and 1.9 million in tier 2) and SAR 5.0 billion (range: SAR 4.0–6.0 billion; people screened: 5.8 million in tier 1 and 2.1 million in tier 2); in Spain, €739 million (range: €591–887 million; people screened: 5.1 million in tier 1 and 1.8 million in tier 2) and €791 million (range: €633–949 million; people screened: 5.4 million in tier 1 and 2.0 million in tier 2); and in the US, \$5.1 billion (range: \$4.1–15.2 billion; people screened: 55 million in tier 1 and 19.7 million in tier 2) and \$3.3 billion (range: \$2.7–10.0 billion; people screened: 36 million in tier 1 and 13.0 million in tier 2). With a 20% LTFU, these costs were lower (Table 2).

TABLE 1 | Estimated T1D and T2D prevalence for 2026–2030, among those aged 20–79 years, based on GBD and IDF data.

	2026		2027		2028		2029		2030	
Brazil										
GBD estimates	15 10409	9.66%	15 561 531	9.87%	16 012 654	10.08%	16 463 776	10.30%	16 914 898	10.52%
IDF estimates	17 587 431	11.24%	17 981 829	11.40%	18 376 226	11.57%	18 770 624	11.74%	19 165 021	11.92%
Germany										
GBD estimates	6 916 552	10.01%	7 134 499	10.31%	7 352 445	10.60%	7 570 392	10.90%	7 788 339	11.20%
IDF estimates	6 432 910	9.31%	6 464 186	9.34%	6 495 462	9.37%	6 526 738	9.40%	6 558 014	9.43%
Japan										
GBD estimates	13 646 994	15.12%	14 018 276	15.67%	14 389 559	16.23%	14 760 841	16.80%	15 132 123	17.38%
IDF estimates	10 721 114	11.88%	10 671 829	11.93%	10 622 543	11.98%	10 573 257	12.03%	10 523 971	12.09%
Kingdom of Saudi Arabia										
GBD estimates	4 443 277	18.33%	4 660 574	18.85%	4 877 870	19.35%	5 095 167	19.84%	5 312 464	20.34%
IDF estimates	5 219 281	21.53%	5 355 329	21.66%	5 491 376	21.78%	5 627 424	21.92%	5 763 471	22.07%
Spain										
GBD estimates	4 793 948	13.02%	4 866 740	13.08%	4 939 531	13.16%	5 012 323	13.24%	5 085 114	13.32%
IDF estimates	5 189 038	14.09%	5 252 243	14.12%	5 315 448	14.16%	5 378 652	14.20%	5 441 857	14.26%
United States										
GBD estimates	48 541 013	19.31%	50 049 088	19.83%	51 557 162	20.34%	53 065 237	20.85%	54 573 311	21.35%
IDF estimates	35 320 879	14.05%	35 472 757	14.06%	35 624 636	14.06%	35 776 514	14.06%	35 928 393	14.06%

Abbreviations: GBD, Global Burden of Disease; IDF, International Diabetes Federation; T1D, type 1 diabetes; T2D, type 2 diabetes. GBD projections were done from the year 2017 to the year 2030. IDF projections were done from the year 2021 to the year 2030.

4.2 | Direct Healthcare Costs for Strategy 2: Biennial Screening

The total costs for Strategy 2 (biennial screening), based on GBD and IDF estimates respectively and assuming a 10% LTFU, were as follows: in Brazil, R\$1.5 billion (range: R\$1.2–1.8 billion; people screened: 26.0 million in tier 1 and 9.2 million in tier 2) and R\$1.7 billion (range: R\$1.4–2.0 billion; people screened: 29.0 million in tier 1 and 10.4 million in tier 2); in Germany, €783 million (range: €627–940 million; people screened: 11.8 million in tier 1 and 4.2 million in tier 2) and €660 million (range: €528–792 million; people screened: 9.9 million in tier 1 and 3.6 million in tier 2); in Japan, ¥218 billion (range: ¥175–262 billion; people screened: 23.0 million in tier 1 and 8.2 million in tier 2) and ¥152 billion (range: ¥121–182 billion; people screened: 16.0 million in tier 1 and 5.7 million in tier 2); in the KSA, SAR 7.1 billion (range: SAR 5.7–8.5 billion; people screened: 8.0 million in tier 1 and 2.9 million in tier 2) and SAR 7.7 billion (range: SAR 6.1–9.2 billion; people screened: 8.7 million in tier 1 and 3.1 million in tier 2); in Spain, €1.1 billion (range: €0.9–1.4 billion; people screened: 7.7 million in tier 1 and 2.8 million in tier 2) and €1.2 billion (range: €1.0–1.4 billion; people screened: 8.2 million in tier 1 and 3.0 million in tier 2); and in the United States, \$7.7 billion (range: \$6.2–23.2 billion; people screened: 83.0 million in tier 1 and 30.0 million in tier 2) and \$5.1 billion (range: \$4.1–15.3 billion; people screened: 54.4 million in tier 1 and 20.0 million in tier 2). With a 20% LTFU these costs were

lower for all countries except the KSA, since the cost of first-line screening in this country is high enough that the required FIB-4 retesting of people LTFU leads to higher costs as LTFU rates increased (Table 3).

5 | Discussion

This study estimated the direct healthcare costs of screening for MASLD and MASH among individuals living with diabetes in six countries, employing two alternative strategies. Findings demonstrated that costs varied by country due to differences in cost inputs, population sizes and diabetes prevalence estimates, as well as across countries due to the different testing methods employed and estimates used. As expected, the second strategy studied incurred higher costs, as it included retesting those who initially tested negative or were LTFU, 2 years later. Given that MASLD can progress silently and that individuals with diabetes, especially T2D, are at higher risk of fibrosis progression, periodic retesting, as in Strategy 2, better reflects the clinical need for long-term monitoring [6, 24, 43]. Although the screening strategies proposed in this study have been demonstrated to be cost-effective [22], some experts still recommend annual retesting for people with two or more cardiometabolic risk factors [24].

Screening for MASLD and MASH could be integrated into existing care pathways for people living with diabetes, much

TABLE 2 | Strategy 1 costs: Among those aged 20–79 years and within the proposed 5-year timeline, with a 10% and 20% LTFU and a lower and higher cost scenario.

Screening strategy 1		Baseline cost	Cost factor –20%	Cost factor +20%	Baseline cost	Cost factor –20%	Cost factor +20%
Country		Baseline LTFU			High LTFU		
		10%			20%		
Brazil (GBD data)							
Overall total costs (local currency)		922 340 382	737 872 306	1 106 808 459	877 950 999	702 360 799	1 053 541 198
Overall total costs (in US\$)		378 008 353	302 406 683	453 610 024	359 815 983	287 852 786	431 779 180
Prevalence of T1D+T2D in year 2030				169 148 98			
People screened in tier 1				169 148 98			
People screened in tier 2			6 089 363			5 412 767	
Brazil (IDF data)							
Overall total costs (local currency)		1 045 035 745	836 028 596	1 254 042 894	994 741 414	795 793 131	1 193 689 696
Overall total costs (in US\$)		428 293 338	342 634 670	513 952 006	407 680 907	326 144 726	489 217 089
Prevalence of T1D+T2D in year 2030				19 165 021			
People screened in tier 1				19 165 021			
People screened in tier 2			6 899 408			6 132 807	
Germany (GBD data)							
Overall total costs (local currency)		513 770 224.86	411 016 179.89	616 524 269.84	491 234 922.81	392 987 938.25	589 481 907.37
Overall total costs (in US\$)		666 368 644.44	533 094 915.55	799 642 373.33	637 139 977.70	509 711 982.16	764 567 973.25
Prevalence of T1D+T2D in year 2030				7 788 339			
People screened in tier 1				7 788 339			
People screened in tier 2			2 803 802			2 492 268	
Germany (IDF data)							
Overall total costs (local currency)		432 609 907.89	346 087 926.31	519 131 889.47	413 634 509.02	330 907 607.22	496 361 410.82
Overall total costs (in US\$)		561 102 344.87	448 881 875.89	673 322 813.84	536 490 932.58	429 192 746.06	643 789 119.10
Prevalence of T1D+T2D in year 2030				6 558 014			
People screened in tier 1				6 558 014			

(Continues)

TABLE 2 | (Continued)

Screening strategy 1		Baseline cost	Cost factor –20%	Cost factor +20%	Baseline cost	Cost factor –20%	Cost factor +20%
Country		Baseline LTFU		High LTFU			
		10%		20%			
People screened in tier 2		2 360 885		2 098 565			
Japan (GBD data)							
Overall total costs (local currency)		143 144 652 889.74	114 515 722 311.79	171 773 583 467.68	137 039 464 366.09	109 631 571 492.87	164 447 357 239.31
Overall total costs (in US\$)		1 510 442 681.12	1 208 354 144.90	1 812 531 217.34	1 446 021 571.87	1 156 817 257.50	1 735 225 886.24
Prevalence of T1D+T2D in year 2030		15132123					
People screened in tier 1		15132123					
People screened in tier 2		5 447 564		4 842 279			
Japan (IDF data)							
Overall total costs (local currency)		99 553 132 723.64	79 642 506 178.91	119 463 759 268.37	95 307 143 571.21	76 245 714 856.97	114 368 572 285.46
Overall total costs (in US\$)		1 050 470 958.36	840 376 766.69	1 260 565 150.03	1 005 667 865.05	804 534 292.04	1 206 801 438.07
Prevalence of T1D+T2D in year 2030		10 523 971					
People screened in tier 1		10 523 971					
People screened in tier 2		3 788 630		3 367 671			
Kingdom of Saudi Arabia (GBD data)							
Overall total costs (local currency)		4 632 948 420.24	3 706 358 736.19	5 559 538 104.29	4 578 947 645.41	3 663 158 116.32	5 494 737 174.49
Overall total costs (in US\$)		2 351 750 467.13	1 881 400 373.70	2 822 100 560.55	2 324 338 906.30	1 859 471 125.04	2 789 206 687.56
Prevalence of T1D+T2D in year 2030		5 312 464					
People screened in tier 1		5 312 464					
People screened in tier 2		1 912 487		1 699 988			
Kingdom of Saudi Arabia (IDF data)							
Overall total costs (local currency)		5 026 267 576.31	4 021 014 061.05	6 031 521 091.58	4 967 682 347.42	3 974 145 877.94	5 961 218 816.91
Overall total costs (in US\$)		2 551 404 861.07	2 041 123 888.86	3 061 685 833.29	2 521 666 166.20	2 017 332 932.96	3 025 999 399.45

(Continues)

TABLE 2 | (Continued)

Screening strategy 1		Baseline cost	Cost factor –20%	Cost factor +20%	Baseline cost	Cost factor –20%	Cost factor +20%
Country		Baseline LTFU		High LTFU			
		10%	20%				
Prevalence of T1D+T2D in year 2030			5 763 471				
People screened in tier 1			5 763 471				
People screened in tier 2		2074850			1 844 311		
Spain (GBD data)							
Overall total costs (local currency)		738 875 493.40	591 100 394.72	886 650 592.08	716 132 092.04	572 905 673.64	859 358 510.45
Overall total costs (in I\$)		1 285 000 858.09	1 028 000 686.47	1 542 001 029.71	1 245 447 116.60	996 357 693.28	1 494 536 539.92
Prevalence of T1D+T2D in year 2030				5085 114			
People screened in tier 1				5085 114			
People screened in tier 2		1 830 641			1 627 236		
Spain (IDF data)							
Overall total costs (local currency)		790 710 880.98	632 568 704.78	948 853 057.17	766 371 929.31	613 097 543.45	919 646 315.17
Overall total costs (in I\$)		1 375 149 358.22	1 100 119 486.58	1 650 179 229.86	1 332 820 746.62	1 066 256 597.30	1 599 384 895.94
Prevalence of T1D+T2D in year 2030				5441 857			
People screened in tier 1				5441 857			
People screened in tier 2		1 959 069			1 741 394		
United States (GBD data)							
Overall total costs (local currency)		5 074 030 083.77	4 059 224 067.02	15 222 090 251.32	4 955 816 079.06	3 964 652 863.25	14 867 448 237.18
Overall total costs (in I\$)		5 074 030 083.77	4 059 224 067.02	15 222 090 251.32	4 955 816 079.06	3 964 652 863.25	14 867 448 237.18
Prevalence of T1D+T2D in year 2030				54 573 311			
People screened in tier 1				54 573 311			
People screened in tier 2		19 646 392			17 463 460		
United States (IDF data)							
Overall total costs (local currency)		3 340 492 679.19	2 672 394 143.35	10 021 478 037.58	3 262 666 373.31	2 610 133 098.65	9 787 999 119.94

(Continues)

TABLE 2 | (Continued)

Screening strategy 1		High LTFU			
Country		10%		20%	
		Baseline LTFU	Cost factor –20%	Cost factor +20%	Baseline cost
Overall total costs (in I\$)		2 672 394 143.35	10 021 478 037.58	3 262 666 373.31	2 610 133 098.65
Prevalence of T1D+T2D in year 2030					9 787 999 119.94
People screened in tier 1			35 928 393		
People screened in tier 2		12 934 221	35 928 393		11 497 086

Abbreviations: GBD, Global Burden of Disease; I\$, international dollar; IDF, International Diabetes Federation, LTFU, lost to follow-up; T1D, type 1 diabetes; T2D, type 2 diabetes.

like screening for other diabetes-related complications such as peripheral neuropathy or diabetic retinopathy, which are already well established and cost-effective. Embedding liver screening into diabetes care could leverage peoples' routine healthcare interactions and shift care towards a more holistic model, rather than a single-disease focus [44]. This approach was proven to be feasible in a Swedish cross-sectional study, which embedded MASLD screening into retinopathy screening and achieved a high uptake, with 77.2% of eligible participants completing the MASLD screening [45]. Additionally, a cost-utility analysis from the United Kingdom demonstrated that applying a two-tiered FIB-4/ELF or FIB-4/VCTE algorithm, as modelled here, effectively reduced unnecessary hepatology referrals by 33.7% and 40.6%, respectively [46]. As several factors can influence the cost of a screening strategy, it is important to clearly define the screening pathway and identify all of the resources involved.

The availability of resources to screen eligible populations is also a critical determinant that must be considered. In Brazil, for instance, the ELF test is not currently available but was incorporated into the model from 2028 onwards, anticipating that this or a similar blood-based biomarker test will be widely available in the country by then. Additionally, the screening setting must be carefully considered. In low-prevalence populations, diagnostic yield is lower and the positive predictive value decreases, leading to more false positives, higher human resource use and increased costs [40]. In this study, however, screening was targeted to people living with diabetes—a higher-risk population—where the diagnostic yield is expected to be higher. Although the potential for overdiagnosis could lead to more follow-up investigations and treatments—and thus to an underestimation of real-world expenditures in our study—other factors should also be considered, including the future incorporation of new technologies and diagnostic pathways (e.g., intelligent liver function testing) [47] and the variability of LTFU in real-world settings [48].

As mentioned, the LTFU population is another key aspect to consider when implementing screening strategies and considering retention strategies, such as peer support and digital applications, could make screening efforts more effective and efficient, as first-line retesting rates would decrease. In this study, we assumed two different LTFU percentages (10% and 20%). However, as the reported LTFU variation in the literature was large [48] there may be different levels, depending on the population and setting. Certain subgroups—such as those with limited health literacy or from lower socioeconomic means—may be disproportionately LTFU or excluded from follow-up pathways, highlighting the need for equity-focused strategies within universal screening programmes to avoid exacerbating existing health disparities, as shown in studies of diabetes care access in rural settings [49, 50]. Policymakers may also choose to begin screening within the T2D population, given that MASLD prevalence in this group is estimated to be twice as high as the general population [5], making it an 'indicator condition' for MASLD testing. However, real-world evidence remains limited, underscoring the need for further evaluation of the impact of such screening approaches in practice.

This study has several limitations. First, total screening costs may be overestimated as individuals already engaged in care

TABLE 3 | Strategy 2 costs: Among those aged 20–79 years and within the proposed 5-year timeline, with a 10% and 20% LTFU and a lower and higher cost scenario.

Screening strategy 2						
Country	Baseline cost	Cost factor –20%	Cost factor +20%	Baseline cost	Cost factor –20%	Cost factor +0%
	Baseline LTFU			High LTFU		
	10%			20%		
Brazil (GBD data)						
Overall total costs (local currency)	1 491 721 313	1 193 377 050	1 790 065 575	1 446 514 453	1 157 211 562	1 735 817 343
Overall total costs (in I\$)	611 361 194	489 088 955	733 633 433	592 833 792	474 267 034	711 400 550
Prevalence of T1D + T2D in year 2030			16 914 898			
People screened in tier 1		25 587 627			26 096 251	
People screened in tier 2		9 211 546			8 350 800	
Brazil (IDF data)						
Overall total costs (local currency)	1 690 159 211	1 352 127 369	2 028 191 054	1 638 938 658	1 311 150 926	1 966 726 389
Overall total costs (in I\$)	692 688 201	554 150 561	831 225 842	671 696 171	537 356 937	806 035 405
Prevalence of T1D + T2D in year 2030			19 165 021			
People screened in tier 1		28 991 449			29 567 734	
People screened in tier 2		10 436 922			9 461 675	
Germany (GBD data)						
Overall total costs (local currency)	783 395 051.05	626 716 040.84	940 074 061.25	764 192 255.21	611 353 804.17	917 030 706.25
Overall total costs (in I\$)	1 016 076 590.20	812 861 272.16	1 219 291 908.24	991 170 240.22	792 936 192.17	1 189 404 288.26
Prevalence of T1D + T2D in year 2030			7 788 339			
People screened in tier 1		11 781 632			12 015 824	
People screened in tier 2		4 241 387			3 845 064	
Germany (IDF data)						
Overall total costs (local currency)	659 642 082.15	527 713 665.72	791 570 498.58	643 472 753.26	514 778 202.61	772 167 303.91
Overall total costs (in I\$)	855 566 902.92	684 453 522.34	1 026 680 283.50	834 595 010.72	667 676 008.57	1 001 514 012.86
Prevalence of T1D + T2D in year 2030			6 558 014			
People screened in tier 1		9 920 487			10 117 683	
People screened in tier 2		3 571 375			3 237 659	

(Continues)

TABLE 3 | (Continued)

Screening strategy 2						
Country	Baseline cost	Cost factor –20%	Cost factor +20%	Baseline cost	Cost factor –20%	Cost factor +0%
		Baseline LTFU			High LTFU	
		10%			20%	
Japan (GBD data)						
Overall total costs (local currency)	218 266 468 608.89	174 613 174 887.11	261 919 762 330.66	213 186 181 322.86	170 548 945 058.29	255 823 417 587.43
Overall total costs (in I\$)	2 303 117 744.11	1 842 494 195.28	2 763 741 292.93	2 249 511 251.69	1 799 609 001.35	2 699 413 502.03
Prevalence of T1D + T2D in year 2030			15 132 123			
People screened in tier 1		22 890 774			23 345 791	
People screened in tier 2		8 240 679			7 470 653	
Japan (IDF data)						
Overall total costs (local currency)	151 798 270 350.19	121 438 616 280.15	182 157 924 420.23	148 265 071 559.66	118 612 057 247.73	177 918 085 871.60
Overall total costs (in I\$)	1 601 754 461.86	1 281 403 569.49	1 922 105 354.23	1 564 472 634.37	1 251 578 107.50	1 877 367 161.25
Prevalence of T1D + T2D in year 2030			10 523 971			
People screened in tier 1		15 919 898			16 236 349	
People screened in tier 2		5 731 163			5 195 632	
Kingdom of Saudi Arabia (GBD data)						
Overall total costs (local currency)	7 064 303 629.36	5 651 442 903.49	8 477 164 355.23	7 123 264 583.07	5 698 611 666.45	8 547 917 499.68
Overall total costs (in I\$)	3 585 940 928.61	2 868 752 742.89	4 303 129 114.33	3 615 870 346.73	2 892 696 277.39	4 339 044 416.08
Prevalence of T1D + T2D in year 2030			5 312 464			
People screened in tier 1		8 036 309			8 196 053	
People screened in tier 2		2 893 071			2 622 737	
Kingdom of Saudi Arabia (IDF data)						
Overall total costs (local currency)	7 664 035 309.87	6 131 228 247.89	9 196 842 371.84	7 728 001 817.37	6 182 401 453.89	9 273 602 180.84
Overall total costs (in I\$)	3 890 373 253.74	3 112 298 602.99	4 668 447 904.49	3 922 843 562.12	3 138 274 849.69	4 707 412 274.54
Prevalence of T1D + T2D in year 2030			5 763 471			
People screened in tier 1		8 718 560			8 891 865	
People screened in tier 2		3 138 682			2 845 397	

(Continues)

TABLE 3 | (Continued)

Screening strategy 2

Country	Baseline cost	Cost factor –20%	Cost factor +20%	Baseline cost	Cost factor –20%	Cost factor +0%
	Baseline LTFU					High LTFU
		10%				20%
Spain (GBD data)						
Overall total costs (local currency)	1 126 634 781.19	901 307 824.95	1 351 961 737.42	1 114 054 748.62	891 243 798.90	1 336 865 698.35
Overall total costs (in I\$)	1 959 364 836.85	1 567 491 869.48	2 351 237 804.22	1 937 486 519.34	1 549 989 215.48	2 324 983 823.21
Prevalence of T1D + T2D in year 2030			5085 114			
People screened in tier 1		7 692 390			7 845 297	
People screened in tier 2		2 769 260			2 510 495	
Spain (IDF data)						
Overall total costs (local currency)	1 205 673 199.78	964 538 559.83	1 446 807 839.74	1 192 210 622.23	953 768 497.78	1 430 652 746.68
Overall total costs (in I\$)	2 096 822 956.14	1 677 458 364.91	2 516 187 547.37	2 073 409 777.79	1 658 727 822.23	2 488 091 733.35
Prevalence of T1D + T2D in year 2030			5441 857			
People screened in tier 1		8 232 045			8 395 680	
People screened in tier 2		2963 536			2 686 618	
United States (GBD data)						
Overall total costs (local currency)	7 736 863 415.04	6 189 490 732.03	23 210 590 245.11	7 709 541 993.03	6 167 633 594.43	23 128 625 979.10
Overall total costs (in I\$)	7 736 863 415.04	6 189 490 732.03	23 210 590 245.11	7 709 541 993.03	6 167 633 594.43	23 128 625 979.10
Prevalence of T1D + T2D in year 2030			54 573 311			
People screened in tier 1		82 554 532			84 195 530	
People screened in tier 2		29 719 632			26 942 570	
United States (IDF data)						
Overall total costs (local currency)	5 093 571 612.92	4 074 857 290.34	15 280 714 838.77	5 075 584 527.97	4 060 467 622.37	15 226 753 583.90
Overall total costs (in I\$)	5 093 571 612.92	4 074 857 290.34	15 280 714 838.77	5 075 584 527.97	4 060 467 622.37	15 226 753 583.90
Prevalence of T1D + T2D in year 2030			35 928 393			
People screened in tier 1		54 349 857			55 430 210	
People screened in tier 2		19 565 949			17 737 667	

for liver-related conditions were not excluded from the target population. Second, the cost analysis was limited only to direct healthcare costs based on public reimbursement rates, which may not reflect actual expenditures. In the US, costs were estimated using Medicare fee schedules, which likely underestimates costs across private healthcare systems. Similarly, fee schedule-based estimates in the other countries studied may not reflect private sector variations. Moreover, non-direct medical costs (e.g., administrative, consumable or infrastructure ones) were not included, as the analyses assumed that these resources were already available. This assumption may not always hold true and could lead to underestimating the total costs of screening. For instance, in Japan, annual health check-ups funded by employers are legally mandated for all workers and include liver function tests but not platelet counts [51], which are required for calculating the FIB-4 index. Adding platelet counts to these routine health check-ups would enable their utilisation as a primary screening tool for liver fibrosis.

Few cost studies that estimate the budget impact of MASLD and MASH screening strategies across multiple countries have been published, especially using a forward-looking approach when considering potential cost variations across different strategies. This study contributes by providing cost estimates for six countries spanning three continents and four WHO regions. However, additional studies need to be carried out in more countries, which use more granular data inputs, taking into account, for example, regional cost variations within countries like Germany and Spain, which have decentralised health systems.

A notable strength of this study is the inclusion of individuals living with T1D, not just T2D, in MASLD and MASH screening cost estimates, an approach not commonly taken in prior analyses. This broader scope aligns with the 2025 ADA consensus report, which recommends including people living with T1D, particularly those with comorbidities such as overweight or obesity, in screening strategies [27]. While this increases projected costs, despite people living with T1D representing a smaller portion of the diabetes population, the study does not specifically target individuals living with T1D who, in addition to their condition, also have comorbidities such as overweight or obesity, as recommended by the ADA [27].

Future studies should also analyse how many new cases of fibrosis would be identified in each of the strategies and, likewise, which treatments would likely be prescribed and their cost. Additionally, calculations could be made as to the number of major adverse cardiologic or liver events that could be prevented via these approaches [52, 53]. Given the natural history and high global prevalence of MASLD, along with its substantial risk of progression to liver fibrosis in those living with diabetes, screening should be integrated into broader NCD action plans, particularly within diabetes strategies. It should also be prioritised within policies such as the WHO ‘best buys’, which are cost-effective policy options for five highly prevalent NCDs [54, 55], as well within the new ‘quick buys’ framework [35] and the UN General Assembly political declarations.

In conclusion, this study offers valuable, time-bound cost estimates to help policymakers and healthcare managers integrate

MASLD and MASH screening strategies into national health budgets, inform economic planning and raise awareness of the growing burden of this neglected, high prevalence NCD.

Author Contributions

J.V.L. – conceptualisation, funding acquisition, investigation, methodology, supervision, validation, writing – original draft, and writing – review and editing. **L.A.-G., J.E.M.-S.** – investigation, methodology, visualisations, writing – original draft, and writing – review and editing. **M.I.M., S.P.** – validation, writing – original draft, and writing – review and editing. **F.T., C.A.V.-N., H.A.A.-O., S.A.A., L.M.Y.A., M.B., K.C., S.D.I., D.M., T.M., R.O.M., S.N., J.M.P., M.R., H.T.** – validation, and writing – review and editing. **N.B.** – investigation, methodology, supervision, visualisations, writing – original draft, and writing – review and editing.

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Ethics Statement

The authors have nothing to report.

Conflicts of Interest

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Data Availability Statement

Data will be made available by the corresponding author upon a fair use request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** liv70390-sup-0001-Tables.docx. **Table S1:** Costs of each of the components included in the study, in local currencies and international dollars (I\$) for the year 2023.