

SYSTEM AND METHOD FOR COMPREHENSIVE HEALTH INDEX CALCULATION AND PERSONALIZED WELLNESS MANAGEMENT

BACKGROUND

Technical Field

5 [0001] The present disclosure relates to computer-implemented health informatics, and more particularly to systems, methods, and computer program products for acquiring multi-source physiological and questionnaire data, normalising such data to a common scale, computing domain-level sub-scores, aggregating the sub-scores into a composite personal health index, and generating risk classifications and decision-support outputs for end-users
10 and clinicians, including embodiments employing rule-based logic and/or machine-learning techniques for weighting, thresholding, and prediction within a secure, role-based computing environment.

Description of the Related Art

15 [0002] Conventional personal health assessment is fragmented, relying on isolated, static measurements (e.g., BMI, blood pressure, step counts) that are interpreted in silos and therefore fail to express whole-person status or support timely, individualized interventions.

 [0003] Existing consumer wearables and single-purpose medical devices collect narrow bands of data without a unifying analytic framework; outputs are typically descriptive
20 rather than integrative, leaving end-users and clinicians without an interpretable composite view across physical, metabolic, immune, and psychosocial domains.

[0004] Where lifestyle or symptom surveys are used, such inputs are frequently static and prone to bias, and they are not systematically reconciled with objective biomarkers or performance metrics, thereby limiting their utility for risk stratification or longitudinal tracking.

5 [0005] Heterogeneous data sources—wearable vendor clouds, clinic devices, imaging systems, laboratory reports, and third-party applications—expose divergent formats, units, and transport protocols, creating persistent challenges in ingestion, validation, harmonisation, and provenance management.

[0006] In the absence of an explicit normalisation procedure, heterogeneous metrics
10 cannot be compared or aggregated; domain-specific indices exist but do not provide a bounded, interpretable scale suitable for cross-domain sub-scoring, composite index formation, and cohort-aware thresholding.

[0007] Feedback cycles in current solutions are delayed or sporadic, often contingent on manual professional review, and do not reliably couple objective measures (e.g., VO₂max, ApoB, grip strength) with subjective inputs (e.g., stress, quality of life) to generate
15 actionable, prioritised recommendations.

[0008] Security, privacy, and governance requirements—including role-based access, least-privilege controls, encrypted transport and storage, auditability, and retention policies—are unevenly implemented across disparate systems, impeding safe and scalable multi-source
20 health processing.

[0009] Accordingly, there is a need for computer-implemented systems and methods that (i) acquire and validate heterogeneous health data; (ii) normalise disparate metrics onto a common bounded scale; (iii) compute domain-level sub-scores and aggregate them into a

composite health index with context-sensitive weighting; and (iv) classify risk to drive timely decision-support outputs for end-users and clinicians.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

5 [00010] In a preferred embodiment, a computer-implemented system acquires heterogeneous health data for a subject across multiple domains comprising muscle health, cardiovascular or cardiorespiratory fitness, immune and inflammaging, diet and gut quality, stress, quality of life, and lifestyle risk. The system includes network-connected clients (mobile and web), integration gateways for third-party vendor clouds, interfaces to clinical
10 devices and information systems, secure data stores, and an analytics service configured to normalise, score, classify, and generate decision-support outputs.

[00011] Data ingestion is performed via authenticated application programming interfaces (APIs) and secure file exchange. Wearable-sourced time-series metrics (e.g., heart rate variability, activity, sleep) are retrieved from vendor clouds through an integration
15 gateway. Clinic devices (e.g., dynamometer for grip strength; body-composition analyser for skeletal muscle index and visceral fat) provide device exports or API feeds. Imaging and allied clinical systems communicate via healthcare messaging (e.g., HL7/PACS). Laboratory values and other reports are uploaded as structured files and, where manual entry is permitted, are subject to schema and unit validation. Each record is stamped with provenance
20 metadata including source, acquisition time, and version.

[00012] An ingestion validator harmonises units, detects duplicates, and resolves conflicts where two or more sources provide semantically comparable measurements. In one embodiment, a precedence policy prioritises device-grade data over self-reported values,

while preserving the lower-precedence values in an audit trail. Outlier handling comprises winsorisation in configured quantile bands and device-drift checks based on rolling reference windows.

[00013] The system implements a mathematically explicit normalisation pipeline that maps heterogeneous raw measurements $x_{d,i}$ to a bounded, interpretable scale. In a preferred embodiment, each measure $x_{d,i}$ within domain d is transformed to a 0–100 scale using a min–max mapping $n_{d,i} = 100 \cdot (x_{d,i} - L_{d,i}) / (U_{d,i} - L_{d,i})$, wherein $L_{d,i}$ and $U_{d,i}$ denote curated lower and upper reference bounds. For biomarkers that exhibit U-shaped risk (e.g., certain stress hormones), the mapping may apply a monotone piecewise or logistic function about a clinically determined optimum. Bounds and mappings are version-controlled to preserve longitudinal comparability.

[00014] Within each domain, the system computes a domain sub-score s_d as an aggregation of the normalised metrics: $s_d = \sum_i \alpha_{d,i} g_{d,i}(n_{d,i})$, where $g_{d,i}(\cdot)$ are monotone shaping functions and $\alpha_{d,i}$ are non-negative weights summing to unity. In a preferred embodiment, shaping functions implement capped ramps for threshold-type measures and smooth sigmoids for continuous risk gradients, thereby enhancing stability against spurious fluctuations.

[00015] A composite health index S is then produced as a weighted aggregation of the domain sub-scores: $S = \sum_d w_d(\pi) s_d$, where $w_d(\pi)$ are domain weights and π is a context vector comprising at least one of age band, sex, and declared or detected co-morbidities. Novel to the present disclosure is a dynamic weighting mechanism wherein the weights are selected or adapted based on subject context and sentinel marker states, enabling the

composite index to reflect clinically appropriate emphasis across domains without re-engineering the entire scoring model.

[00016] In one preferred embodiment, the dynamic weighting employs a clinician-defined matrix indexed by context factors, such that for a subject with dyslipidaemia, the cardiovascular domain receives a higher initial weight than lifestyle or stress. In another preferred embodiment, the system applies constrained updates Δw_d to weight vectors when sentinel markers (for example, apolipoprotein B, lipoprotein(a), or cardiorespiratory performance) cross configurable thresholds; the constraints enforce non-negativity and unity sum to preserve interpretability of the 0–100 scale.

[00017] The system further implements guard-rail logic that modifies the composite health index when risk in critical domains would otherwise be obscured by favourable values elsewhere. In an illustrative embodiment, if cardiovascular sentinels exceed thresholds, the composite index is capped at a ceiling value unless corroborated mitigating evidence (for example, superior VO₂max and low systemic inflammation) is concurrently present. For immune-inflammatory risk, a penalty term may be subtracted from S when inflammation markers exceed thresholds, thereby preventing false reassurance from non-immune domains.

[00018] Risk communication is provided via traffic-light classification on the composite scale and, optionally, per-domain scales. In a preferred embodiment, the composite index is mapped to bands Green, Yellow, and Red using fixed thresholds (e.g., ≥ 70 , 50–69.9, <50). In a further embodiment, cohort-adaptive cut-offs are computed using demographic percentiles to accommodate population differences while retaining compatibility with the bounded 0–100 scale.

[00019] The system generates decision-support outputs comprising a subject dashboard with longitudinal trends, a clinician-oriented report, and alerts or notifications when band transitions occur or when sentinel markers cross configured limits. Each output enumerates contributing domains, highlights principal drivers of deviation, and optionally provides a rationale trace describing the path from raw metrics through normalisation and weighting to the final index and classification.

[00020] In a preferred embodiment, the system includes an optional rule-based recommender that maps domain deviations to evidence-linked actions, such as referral prompts for lipid management when cardiovascular markers are sub-optimal, or graded aerobic protocols when cardiorespiratory fitness is below target. Rules are versioned, and the outputs are parameterised to the subject's context vector π .

[00021] In an additional embodiment, the system comprises a predictive module that estimates short-horizon risk of transition into a worse band (e.g., to Red within a forecast window). Features may include slopes and variability of domain sub-scores and selected raw metrics; models may be drawn from gradient-boosted ensembles or temporal convolutional architectures. Predictions are surfaced with calibrated probabilities and confidence intervals, and are expressly optional so that the core index and classification remain operable without machine learning.

[00022] To facilitate safe operation in clinical and consumer contexts, the system enforces security and governance controls. Transport security employs modern cryptographic protocols; access is mediated by role-based access control with least-privilege scopes for roles including subject (end-user), clinician or consultant, administrative/operations staff, and system administrator. At-rest encryption, immutable audit logs, and data-retention and

deletion policies are provided. Consent management records granular permissions for sharing data and reports with designated recipients, including telehealth channels.

[00023] The architecture may be deployed in a single-tenant or logically isolated multi-tenant cloud configuration. Each tenant maintains separate key material for encryption and audit purposes. Administrative consoles support role assignment, key rotation, rules and threshold updates, and export of de-identified aggregates for cohort analytics where permitted by consent.

[00024] In a preferred embodiment, governance processes require periodic (e.g., annual) review of clinical reference bounds, threshold bands, and rules. Updates are versioned; historical records retain their original mappings to preserve the integrity of longitudinal comparisons, while forward computations apply the updated mappings. The system thereby reconciles the need to incorporate evolving clinical guidance with the requirement to maintain comparability over time.

[00025] The disclosed pipeline supports reconciliation of subjective inputs with objective biomarkers. For example, stress-related survey responses are used to initialise or modulate shaping functions within the stress domain, but are reconciled against physiological correlates (e.g., heart rate variability) via bounded influence so that subjective bias does not dominate the composite. This reconciliation is a novel design choice that increases robustness without discarding valuable self-reported information.

[00026] In operation, a worked example proceeds as follows. A subject's grip strength, skeletal muscle index, visceral fat, VO₂max, lipid markers, inflammation marker, diet quality score, sleep efficiency, and lifestyle behaviours are ingested and validated. Each is normalised to 0–100 using current reference bounds; domain sub-scores are computed; the

dynamic weighting matrix selects higher weight for cardiovascular risk in view of elevated apolipoprotein B; guard-rails cap the composite pending improvement in sentinel markers; and the output displays a composite index of 62 (Yellow) with targeted actions and an alert to schedule follow-up.

5 [00027] The disclosure extends to a computer system comprising one or more processors and memory storing instructions that, when executed, implement the foregoing ingestion, validation, normalisation, sub-scoring, dynamic weighting, guard-rail, classification, and output functions. The disclosure further extends to a non-transitory computer-readable storage medium storing instructions for causing a processor to perform
10 any of the methods herein described, and to data structures representing versioned reference bounds, shaping functions, weight matrices, rules, and governance artefacts.

 [00028] It is to be understood that the foregoing embodiments are illustrative and not limiting. Variations in data sources, normalisation mappings, aggregation schemes, and classification thresholds that preserve the essential characteristics of bounded-scale
15 normalisation, context-dependent dynamic weighting, guard-rail adjustment based on sentinel markers, and auditably secure processing fall within the scope of the present disclosure as would be appreciated by a person skilled in the art.

DESCRIPTION OF THE RELATED FIGURES

20 [00029] FIG. 1 is a system and data-flow diagram showing the Core Tulah platform integrating mobile and web clients via an API gateway with wearable devices, third-party applications, and medical equipment. Bidirectional flows include guest data and payments, report uploads, approvals and schedules, genomics and activity data, and assessment results

including radiology values.

[00030] FIG. 2 is a system and data-flow diagram showing mobile/web clients, third-party vendor clouds (wearables via an integration API), clinic devices (VALD DynaMo, InBody 970), and PACS/HL7 feeding an ingestion and validation layer. The validated data
5 write to secure storage and then flow through normalization, sub-scoring, dynamic weighting, classification, guard-rails, and output modules.

[00031] FIG. 3 is a normalization and scoring flowchart illustrating min-max mapping of heterogeneous inputs to a 0–100 scale with illustrative numerics. The normalized metrics aggregate into domain sub-scores and then a composite index S using dynamic, context-
10 dependent weights.

[00032] FIG. 4 is a classifier and guard-rail logic diagram depicting Green/Yellow/Red thresholds with cohort-adaptive alternatives. Guard-rail caps and penalties are applied when sentinel cardiovascular or immune markers indicate elevated risk.

[00033] FIG. 5 is a device acquisition and manual-entry validation diagram showing
15 VALD DynaMo grip capture, InBody 970 SMI/visceral-fat capture, VO_2 max in-house testing, and pathology report uploads. Schema/unit checks, outlier handling, and provenance logging ensure data integrity before downstream analysis.

DETAILED DESCRIPTION OF THE INVENTION

20 [00034] The Tulâh Life Index System is designed to function seamlessly through multiple interconnected modules, enabling end-to-end health monitoring, analysis, and personalized recommendations. The flowcharts illustrate the detailed workings of each module, from data collection to real-time feedback and machine learning integration. These

components interact systematically to ensure users receive timely insights into their health, empowering them to take proactive measures for well-being.

[00035] The data collection module serves as the starting point of the system. It gathers health metrics from a variety of sources, including wearable devices, standalone medical
5 equipment, manual user inputs, and third-party health applications. Wearable devices like smartwatches capture real-time data such as heart rate, VO2 Max, and sleep cycles. Standalone devices, such as InBody analyzers, provide important readings like grip strength, skeletal muscle index, and visceral fat levels. Additionally, users log subjective inputs—such as stress levels or lifestyle habits—through the app interface. The system also integrates with
10 external platforms like Google Fit and Apple Health via secure API connections to gather relevant data.

[00036] After collection, the data flows into the aggregation module, where it is validated and formatted for further analysis. The system checks for missing or duplicate entries and resolves any inconsistencies to maintain data integrity. Standardization processes
15 ensure that metrics from different sources are converted into consistent units, making them suitable for comparison. Once validated, the data is securely stored in the cloud-based database, allowing real-time access and ensuring redundancy to prevent data loss or service disruptions.

[00037] The core function of the health index calculation module is to process the
20 aggregated data using a normalization method. The method adjusts raw health metrics into standardized ranges, such as converting grip strength and VO2 Max values into age- and gender-specific percentiles. The system assigns weighted importance to each health domain—such as cardiovascular fitness, stress management, and muscle health—based on

their impact on overall well-being. The normalized metrics are then combined to generate a composite Tulâh Life Index score on a scale of 0 to 100, providing a holistic view of the user's health status.

5 [00038] The system further refines the health score through the categorization and threshold management module. The Tulâh Life Index score is classified into three predefined ranges: Green (Optimal) for scores above 70, Yellow (Average) for scores between 50 and 70, and Red (High Risk) for scores below 50. This classification helps users quickly assess their health and identify areas that require attention. The system adjusts its recommendations dynamically based on these scores, ensuring relevant feedback for the user.

10 [00039] Users interact with the system through the user interface and visualization module. The interface presents the health index score on a dashboard, along with trend graphs for each health domain. This enables users to track their progress over time and compare current performance with past metrics. If any domain score falls into the high-risk category, the system sends alerts to the user, urging them to take corrective actions. The
15 visual presentation of data helps users engage effectively with their health information.

[00040] The feedback and recommendation module generates personalized wellness recommendations based on the user's health index score and trends. For instance, if a user's cardiovascular fitness is found to be suboptimal, the system may suggest aerobic exercises or dietary adjustments. If stress levels are elevated, it might recommend relaxation techniques
20 such as meditation or yoga. Predictive analytics within the system identify emerging risks, such as declining fitness levels, and offer preventive suggestions accordingly.

[00041] As the system collects more data over time, it leverages machine learning methods to refine recommendations and predict health risks. The machine learning model

analyzes historical data to identify patterns and correlations between various health metrics. For example, the system may detect a relationship between poor sleep quality and increased stress levels. Recommendations evolve adaptively, reflecting the user's changing health patterns, and users receive predictive alerts for potential health risks.

5 [00042] The real-time notification module ensures continuous engagement by sending alerts and reminders to users. Notifications prompt users to complete specific actions, such as drinking water, exercising, or taking breaks for relaxation. Health alerts are triggered if any domain falls into the high-risk category, prompting immediate action. Users also receive reminders about their health goals, motivating them to stay on track and achieve their
10 objectives.

 [00043] The system's data security and authentication module safeguards user information through encryption and multi-factor authentication. All data transmissions are encrypted to prevent unauthorized access. Users log in using two-factor authentication, ensuring that only authorized individuals can access sensitive health information. The system
15 complies with privacy regulations such as HIPAA and GDPR, ensuring that data is handled responsibly and securely.

 [00044] The report generation module creates detailed summaries of the user's health metrics and trends. Monthly or weekly reports highlight progress across different domains and offer actionable insights. These reports are exportable in PDF format, allowing users to
20 share them with healthcare professionals. Doctors can use these reports to provide personalized advice during telehealth consultations, ensuring continuity of care.

 [00045] The system integrates seamlessly with telehealth services, enabling users to schedule virtual appointments with healthcare providers. Health reports are securely shared

with doctors, who can assign specific tasks or goals based on the user's data. This integration supports remote monitoring and continuous engagement between the user and healthcare professionals.

[00046] The goal-setting and tracking module empowers users to set personal health goals based on their index scores. Users can define objectives, such as improving cardiovascular fitness or managing stress, and track their progress over time. The system provides motivational feedback and adjusts recommendations based on goal achievement, fostering continuous improvement.

[00047] The data backup and recovery module ensures that user data is protected through automated cloud backups. In case of system failures, data can be quickly restored from the backup, minimizing downtime. This redundancy provides peace of mind to users, ensuring uninterrupted access to their health information.

[00048] The platform is designed with scalability and modularity, allowing it to grow as more users join and new health technologies emerge. APIs facilitate the integration of additional devices and apps, while the modular design ensures that new features, such as genetic testing modules, can be incorporated without disrupting existing workflows.

[00049] The user feedback mechanism collects insights from users about the platform's recommendations and interface. This feedback is analyzed to refine the system's performance and enhance the user experience. Additionally, a dedicated support system allows users to contact customer service for assistance with any issues they encounter.

[00050] The performance monitoring module tracks the system's operations to ensure optimal functionality. System logs document events and metrics, and automated diagnostics detect potential issues, sending alerts to administrators for resolution. Regular updates

improve performance, security, and usability, keeping the platform up-to-date and effective.

[00051] In conclusion, the flowcharts illustrate the interconnected components of the Tuláh Life Index System, highlighting its ability to collect, process, and analyze health data seamlessly. The platform ensures real-time monitoring, predictive insights, and personalized
5 recommendations, empowering users to take proactive control of their health. Through its emphasis on user engagement, data security, and scalability, the system offers a reliable and adaptive solution for comprehensive wellness management.

[00052] FIG. 1 depicts a preferred system architecture in which the Core Tulah platform (backend and database) (001) orchestrates all acquisition and exchange of health-
10 related information. The platform (001) exposes authenticated interfaces that enforce role-based access control and consent checks while broker-ing bidirectional data flows with client applications and data suppliers. In operation, (001) maintains versioned schemas, unit normalisation rules, and provenance logs so that every incoming payload can be validated, harmonised, and routed to downstream scoring and reporting services described elsewhere in
15 this specification.

[00053] A mobile client (002) communicates with the platform (001) to submit structured inputs and retrieve user-facing outputs. Upstream payloads from (002) include guest details, payments, report uploads, wearable synchronisation triggers, and diet/activity logs; downstream responses include confirmations and updated dashboards. In one
20 embodiment, (001) assigns each submission from (002) an idempotency token and a provenance stamp ({source, device ID, acquisition time, schema version}) to prevent duplication and to preserve a verifiable audit trail, thereby enabling secure consumer-grade capture to feed clinical-grade analytics.

[00054] A web portal (003) provides clinician and operations access to approvals, assessment schedules, and retreat schedules. The inventive integration ensures that schedule objects created or modified at (003) generate event hooks within (001), which then fan out to
5 the appropriate data sources (e.g., wearable sync windows, device bookings) and to notification channels for the subject. Conversely, assessment results and radiology values returned to (003) are assembled by (001) from multiple sources with guaranteed schema compliance, enabling consistent rendering and export without manual reconciliation.

[00055] Third-party applications (004)—including practice management systems and
10 genomics or activity platforms—connect to (001) through contracted APIs. The inventive aspect is that (001) treats (004) as first-class sources and sinks: payloads such as guest feedback, payments, room bookings, genomics sample status, and activity telemetry are accepted with schema validation and unit harmonisation, while responses (e.g., booking confirmations or task states) are propagated back to (004). This two-way integration
15 eliminates operational silos and allows downstream analytics to operate on a single, coherent record.

[00056] Wearable devices (005) interface with (001) via an integration API gateway (006) that abstracts vendor clouds (e.g., Apple, Samsung, Fitbit, Oura, Whoop). Novelty resides in the gateway (006) performing pre-validation and normalised time-alignment before
20 persistence, so that heterogeneous time-series streams arrive at (001) in a canonical form. The platform (001) records gateway provenance and applies deduplication/priority rules when a metric is available from both (005) and other clinical sources, thereby ensuring that consumer-grade streams augment—rather than contaminate—clinical evidence.

[00057] Medical equipment (007) (e.g., VALD DynaMo and PACS-connected systems) delivers assessment results and radiology values directly into (001). The platform's inventive guard-rails require that device-grade payloads from (007) supersede lower-
5 confidence submissions while preserving the latter in an immutable audit store. In one embodiment, (001) enforces bidirectional acknowledgements: when (007) pushes an assessment, (001) returns a signed receipt containing the validated schema hash and storage address, enabling traceable, regulator-ready custody of results subsequently surfaced to (003) and the user via (002).

10 [00058] Collectively, the cooperative operation of (001)–(007) enables a real-time, closed-loop data plane: (002) and (003) originate and consume workflows; (004), (005), and (007) supply objective and contextual signals; and (001) guarantees secure, versioned, and reconciled exchange among them. The proposed arrangement of FIG. 1 is technically advantageous because it (i) collapses heterogeneous sources into a governed canonical
15 record; (ii) supports bidirectional, event-driven updates without manual stitching; and (iii) preserves provenance and priority across consumer and clinical channels, thereby enabling the downstream normalisation, sub-scoring, dynamic weighting, classification, and guard-rail processing described in later.

[00059] FIG. 2 illustrates a preferred system and data-flow arrangement in which
20 mobile/web clients (101), wearable vendor clouds accessed via an integration API (102), clinic devices including VALD DynaMo and InBody 970 (103), and PACS/HL7 imaging systems (104) provide heterogeneous inputs to an ingestion and validation layer (105). The layer (105) terminates authenticated connections, enforces schema conformity, performs unit

harmonisation, executes deduplication and precedence rules for overlapping measures, and stamps each accepted record with provenance identifiers including source, device or system ID, acquisition time and schema version.

[00060] Records that satisfy the validation checks are written to secure storage (106).

- 5 In one embodiment, storage (106) comprises an operational store for current normalised metrics and subject profiles, an object store for raw uploads and pre-validation snapshots, and an analytics/feature store for time-aligned signals. All stores are encrypted at rest and maintain versioned lineages so that subsequent computations are reproducible.

- [00061] Downstream processing is effected by a configured pipeline in which
10 normalisation (107) maps raw measurements to a bounded, interpretable 0–100 scale using curated lower and upper reference bounds, optionally with monotone shaping for U-shaped risk markers. The resulting normalised values are aggregated within each domain by sub-scoring (108), which applies convex combinations of the shaped metrics according to domain-specific weight vectors.

- 15 [00062] A dynamic weighting module (109) then computes a composite index as a weighted aggregation of the domain sub-scores, the weights being selected or adapted with reference to a context vector (e.g., age band, sex, co-morbidities) and/or sentinel biomarker states. The composite index is mapped by classification (110) into risk bands (e.g., Green/Yellow/Red) using predefined or cohort-adaptive thresholds, while guard-rails (111)
20 adjust or cap the index where critical-domain risk would otherwise be masked, for example when cardiovascular or inflammatory sentinels exceed configured limits.

[00063] Outputs generated by the pipeline are delivered by outputs module (112) to user dashboards, clinician reports and notification channels. Each output is accompanied by

computation metadata comprising the bound-set identifier, shaping profile, domain weight vector version and dynamic weight policy version, thereby enabling full traceability of results. The depicted arrangement ensures that heterogeneous clinical and consumer inputs are validated, securely persisted and processed in a deterministic, version-controlled manner
5 suitable for regulatory and clinical use.

[00064] FIG. 3 depicts a normalization and scoring flowchart in which raw inputs $\{d,i\}$ (201) are transformed by min-max mapping (202) to produce normalized values $n\{d,i\} \in [0, 100]$ according to $n\{d,i\} = 100 \cdot (x - L)/(U - L)$, where L and U are curated lower and upper reference bounds. Prior to aggregation, the normalized metrics are optionally passed through
10 monotone shaping functions $g\{d,i\}$ (203)—for example, capped ramps for threshold-type measures or sigmoids for U-shaped risk—thereby stabilizing sensitivity near clinical inflection points while preserving the bounded scale.

[00065] The shaped metrics are combined within each domain by a domain sub-score module (204) implementing a convex aggregation $s_d = \sum_i \alpha_{d,i} g\{d,i\}(\pi\{d,i\})$, where $\alpha_{d,i} \geq 0$
15 and $\sum_i \alpha_{d,i} = 1$. This construction preserves interpretability on the 0-100 scale and limits the influence of any single metric unless explicitly configured by the domain weight vector $\{\alpha_{d,i}\}$.

[00066] A composite index module (205) computes the overall score $S = \sum_d w_d(\pi) s_d$ using dynamic, context-dependent weights $w_d(\pi)$ that are selected or adapted with reference
20 to a subject context vector π (e.g., age band, sex, co-morbidities and/or sentinel biomarker states), with non-negativity and unity-sum constraints on $\{w_d\}$. The flowchart concludes with an illustrative example block (205) that presents a tabulation of normalized values, shaping profiles, intra-domain weights $\{\alpha_{d,i}\}$, selected context π , domain sub-scores $\{s_d\}$, and the

resulting composite index S, thereby enabling deterministic reproduction of the computation.

[00067] FIG. 4 illustrates a classifier and guard-rail logic arrangement wherein a composite index S (0–100) (301) is mapped to discrete risk classes by a thresholds module (302) that, in a preferred embodiment, assigns Green for $S \geq 70$, Yellow for $50 \leq S < 70$, and Red for $S < 50$. The thresholds module (302) emits both the class label and the cut-off set used, enabling deterministic reproduction of class assignments.

[00068] Downstream of thresholding, a guard-rail module (303) applies caps and penalties to prevent critical-domain risk from being masked by favourable values elsewhere. In one embodiment, crossing a cardiovascular sentinel threshold (e.g., elevated ApoB or Lp(a)) triggers a cap on S until corroborating mitigation is present, while elevation of inflammatory markers (e.g., hs-CRP) applies a configurable penalty δ to S. Each adjustment is logged with the triggering sentinel and rule version.

[00069] In a further embodiment, a cohort-adaptive variant (304) replaces or augments fixed cut-offs with percentile-based thresholds computed for the subject's demographic stratum (e.g., age band and sex). The module (304) outputs the percentile mappings used, thereby enabling population-aware classification while preserving auditability and consistency across longitudinal evaluations.

[00070] FIG. 5 illustrates a device acquisition and manual-entry validation arrangement in which VALD DynaMo (grip strength) (401), InBody 970 (skeletal muscle index/visceral fat) (402), VO₂max in-house testing with report upload (403), and laboratory/pathology inputs including ApoB, Lp(a) and RDW via manual entry and report ingestion (404) provide heterogeneous data streams to a validation layer (405). Each incoming record is subjected to schema conformity checks (field presence, type and unit

canonicalisation), range and plausibility checks (including orientation and reference-range mapping), and conflict/deduplication rules where overlapping measures exist.

[00071] The validation layer (405) further implements outlier handling and provenance logging. In one embodiment, statistical winsorisation or rule-based clipping is applied to extreme values prior to persistence; every accepted record is stamped with provenance metadata comprising source identifier, device or instrument ID, acquisition timestamp, operator (where applicable), file hash for uploaded reports, and the validation profile version. Records failing validation are quarantined with structured error codes and are not forwarded downstream.

[00072] Validated data are written to secure storage (406), which maintains encrypted, version-controlled artefacts suitable for deterministic recomputation by the normalisation, sub-scoring, dynamic weighting, classification and guard-rail modules described elsewhere. The arrangement of elements (401)–(406) ensures that both device-generated measurements and manually entered laboratory values achieve data integrity and auditability prior to inclusion in analytical workflows.

SUMMARY OF THE DISCLOSED EMBODIMENTS

[00073] The present disclosure provides computer-implemented systems, methods, and computer program products for generating a bounded, interpretable composite health index from heterogeneous clinical and consumer data sources. The system acquires objective measurements and structured subjective inputs across multiple domains—including muscle health, cardiovascular/cardiorespiratory fitness, immune/inflammaging, diet and gut quality, stress, quality of life, and lifestyle risk—and produces a subject-specific score on a 0–100

scale together with risk classifications and decision-support outputs.

[00074] In one aspect, an ingestion and validation layer receives data from mobile/web clients, wearable vendor clouds via an integration gateway, clinical devices and information systems (including VALD DynaMo, InBody 970, and PACS/HL7), third-party applications, and manual laboratory/report uploads. The layer enforces schema conformity and unit harmonisation, executes deduplication and precedence rules for overlapping measures, applies outlier handling and device-drift checks, and stamps accepted records with provenance identifiers to enable deterministic reproduction and auditability.

[00075] In another aspect, a normalisation pipeline maps raw metrics $\mathbf{x}_{di}$ to a bounded 0–100 scale using curated lower and upper reference bounds, optionally with monotone shaping functions for non-linear or U-shaped risk relationships. Within each domain, shaped metrics are aggregated by a convex combination to form domain sub-scores that preserve interpretability and limit undue influence of any single measurement.

[00076] A composite index is computed as a weighted aggregation of domain sub-scores using dynamic, context-dependent weights $w_d(\pi)$ selected or adapted with reference to a context vector π comprising at least one of age band, sex, and co-morbidities and/or sentinel biomarker states. Constraints on the weights (non-negativity and unity sum) preserve comparability on the 0–100 scale while enabling clinically appropriate emphasis across domains.

[00077] The composite index is mapped to risk classes by a classifier that, in preferred embodiments, assigns Green, Yellow, or Red labels using fixed thresholds and/or cohort-adaptive percentile cut-offs computed for the subject’s demographic stratum. Guard-rail logic applies caps and penalties to prevent critical-domain risk—such as elevated cardiovascular or

inflammatory sentinels—from being obscured by favourable values in other domains, with each adjustment recorded together with the triggering condition and rule version.

[00078] Outputs include user dashboards, clinician-oriented reports, and alerts/notifications on band transitions or sentinel breaches. Optional embodiments comprise
5 a rules-based recommender that maps domain deviations to evidence-linked actions and a predictive module that estimates short-horizon risk of deterioration using features derived from longitudinal metrics, with model families, training cadence, and performance measures defined to ensure calibrated presentation of risk.

[00079] Security and governance features include authenticated and authorised access
10 (role-based access control with least-privilege scopes), encrypted transport and at-rest protection, immutable audit logging, consent management with granular sharing scopes, and retention/deletion policies. Versioning of reference bounds, shaping profiles, intra-domain weight vectors, dynamic-weight policies, classifier thresholds, and guard-rail rules ensures that historical computations remain reproducible and that forward computations adopt
15 updated clinical guidance without silently altering past results.

[00080] The disclosure further provides a computer system comprising one or more processors and memory storing instructions that, when executed, cause the system to perform the foregoing ingestion, validation, normalisation, sub-scoring, dynamic weighting, classification, guard-rail, and output functions; and a non-transitory computer-readable
20 storage medium storing instructions for causing a processor to carry out any of the methods described herein.

[00081] The described architecture confers technical advantages by unifying heterogeneous data into a governed canonical record; enabling robust, bounded normalisation

and context-sensitive aggregation; preventing masking of critical risk through guard-rails; and delivering auditable, real-time outputs suitable for clinical and consumer decision support, while remaining extensible to additional sources, domains, and analytical modules.

[00082] The Tulåh Life Index System is an integrated health monitoring and management platform that provides a holistic assessment of an individual's well-being by
5 collecting and analyzing data from multiple health domains. These domains include muscle health, cardiovascular fitness, immune health, gut health, stress management, quality of life, and lifestyle risk. The system generates a composite health index score on a 0-100 scale, offering users insights into their health status in real-time and guiding them toward
10 personalized wellness goals.

[00083] The system begins by gathering data from wearable devices, standalone medical equipment, manual inputs from users, and third-party health apps. Wearable trackers capture continuous metrics such as heart rate, sleep quality, and activity levels, while medical devices provide more targeted data, such as grip strength and body composition. Subjective
15 inputs, such as self-reported stress and quality of life scores, complement these objective measures. Integration with platforms like Google Fit and Apple Health further enhances the scope of data collection.

[00084] Once collected, the data is validated and standardized by the data aggregation module to ensure accuracy and consistency. Metrics from different sources are converted into
20 comparable units, such as age- and gender-specific percentiles, and stored securely in a cloud-based database. This step ensures real-time accessibility and redundancy, preventing data loss while supporting scalability.

[00085] The heart of the system is the health index calculation module, which applies a

patented normalization method to the aggregated data. The method assigns weights to each health domain based on its significance to overall well-being and generates a composite Tulâh Life Index score. This score provides users with a comprehensive overview of their health, reflecting both physical and mental wellness.

5 [00086] To make the score actionable, the system classifies it into three categories: Green (Optimal), Yellow (Average), and Red (High Risk). This classification allows users to easily understand their health status and prioritize areas that require attention. The user interface presents the health score on a dashboard along with graphs showing trends for each health domain, helping users track their progress over time.

10 [00087] Based on the health score and trends, the feedback module provides personalized recommendations to improve wellness. For example, if cardiovascular health is low, the system may recommend increasing aerobic activities. If stress levels are high, it may suggest relaxation techniques like yoga or meditation. These recommendations are dynamically updated as the user's health evolves, ensuring continuous relevance.

15 [00088] The system also leverages machine learning methods to analyze historical data and identify patterns. Over time, it refines recommendations and offers predictive insights into potential health risks, such as identifying early warning signs of cardiovascular conditions. This predictive capability enables users to take preventive actions proactively.

20 [00089] Engagement is maintained through the real-time notification module, which sends reminders and alerts to users. Notifications may include reminders to stay hydrated, complete exercises, or relax. Users also receive health alerts if their score falls into the high-risk category, prompting immediate action.

[00090] To ensure privacy and security, the platform employs encryption and multi-

factor authentication. Data is transmitted securely, and the system complies with healthcare regulations such as HIPAA and GDPR. This ensures that users' sensitive information is protected throughout the data lifecycle.

[00091] The telehealth integration module allows users to share their health reports
5 with healthcare professionals for remote consultations. The system also facilitates virtual appointments and follow-ups, ensuring continuous monitoring and personalized care. Users can receive tailored advice and action plans based on their Tulåh Life Index score.

[00092] The goal-setting and tracking module further empowers users by enabling
10 them to define personal wellness goals, such as improving cardiovascular fitness or reducing stress levels. The system monitors progress and provides motivational feedback, keeping users engaged and on track toward their objectives.

[00093] The scalable design of the Tulåh Life Index System allows it to grow with
emerging technologies. New devices and apps can be integrated seamlessly, and additional modules, such as genetic testing, can be incorporated without disrupting existing workflows.
15 This ensures the platform remains relevant and adaptive over time.

[00094] In summary, the Tulåh Life Index System offers a comprehensive, real-time,
and adaptive health management solution. By integrating multiple health domains into a single index score, the system provides users with actionable insights and personalized recommendations. Its predictive analytics, telehealth support, and focus on user engagement
20 make it a powerful tool for proactive health management. With an emphasis on security, scalability, and continuous improvement, the Tulåh Life Index System is well-positioned to support users in maintaining and enhancing their well-being over the long term.

Claims of the Invention:

1. A computer-implemented method for generating a composite health index and providing wellness management outputs for a subject, the method comprising:
acquiring heterogeneous health data including objective measurements from one or
5 more devices and information systems and structured subjective inputs across a plurality of health domains; validating the heterogeneous health data by enforcing schema conformity, harmonising units, performing deduplication with source precedence, and recording provenance metadata; normalising respective
10 measurements to a bounded common scale to obtain normalised metrics; computing, for each health domain, a domain sub-score by aggregating the normalised metrics according to a domain weight vector; computing a composite health index as a weighted aggregation of the domain sub-scores using dynamic, context-dependent weights selected or adapted with reference to a context vector associated with the subject; classifying the composite health index into a risk class using predefined
15 and/or cohort-adaptive thresholds; applying guard-rail logic that adjusts or caps the composite health index in response to sentinel biomarker states so as to prevent masking of critical risk; and generating one or more outputs selected from a user dashboard, a clinician report and an alert or notification.
2. The method of claim 1, wherein the plurality of health domains comprise at least
20 muscle health, cardiovascular or cardiorespiratory fitness, immune and inflammaging, diet and gut quality, stress, quality of life and lifestyle risk.
3. The method of claim 1 or claim 2, wherein acquiring the heterogeneous health data comprises receiving time-series data from wearable-device vendor clouds via an

integration gateway, receiving measurements from clinical devices or information systems, and ingesting manual entries and report uploads from client applications.

4. The method of any one of claims 1 to 3, wherein validating comprises quarantining data that fail validation and persisting accepted data together with provenance metadata comprising at least one of: source identifier, device or system identifier, acquisition timestamp, ingestion timestamp, schema version identifier and validation profile identifier.
5. The method of any one of claims 1 to 4, wherein normalising comprises mapping a raw measurement x to a value $n \in [0,100]$ using a mapping determined by curated lower and upper reference bounds and, for non-linear risk relationships, a monotone shaping function.
6. The method of any one of claims 1 to 5, wherein computing the domain sub-score comprises applying a convex aggregation $s_d = \sum_i \alpha_{d,i} g_{d,i}(n_{d,i})$ subject to $\alpha_{d,i} \geq 0$ and $\sum_i \alpha_{d,i} = 1$.
7. The method of any one of claims 1 to 6, wherein computing the composite health index comprises enforcing non-negativity and unity-sum constraints on the dynamic, context-dependent weights and selecting or adapting the weights with reference to a context vector comprising at least one of: age band, sex and co-morbidities.
8. The method of any one of claims 1 to 7, wherein adapting the dynamic, context-dependent weights further comprises applying constrained updates in response to transitions of one or more sentinel biomarkers across configured thresholds.
9. The method of any one of claims 1 to 8, wherein classifying comprises assigning Green, Yellow or Red classes according to fixed thresholds and/or percentile-based

thresholds computed for a demographic cohort of the subject.

10. The method of any one of claims 1 to 9, wherein the guard-rail logic comprises at least one of: capping the composite health index when a cardiovascular sentinel biomarker is outside a configured range; and subtracting a penalty when an inflammatory sentinel biomarker exceeds a configured level.

11. The method of any one of claims 1 to 10, further comprising generating an explainability trace that enumerates normalised metrics, domain sub-scores, selected weight vectors, threshold sets and guard-rail adjustments used to obtain the risk class.

12. The method of any one of claims 1 to 11, further comprising enforcing security controls comprising authenticated and authorised access, encrypted transport, encrypted storage and immutable audit logging.

13. The method of any one of claims 1 to 12, further comprising generating recommendations by applying rule-based mappings from domain deviations to interventions.

14. The method of any one of claims 1 to 13, further comprising estimating a probability of transition to a worse risk class within a forecast horizon using a predictive model trained on features derived from longitudinal metrics, and surfacing a calibrated risk output.

15. The method of any one of claims 1 to 14, wherein normalisation mappings, shaping profiles, domain weight vectors, dynamic-weight policies, threshold sets and guard-rail rules are version-controlled, and wherein historical computations are preserved without silent recomputation when versions change.

16. A system for comprehensive health index calculation and personalised wellness

management, comprising one or more processors and memory storing instructions that, when executed by the one or more processors, cause the system to perform the method of any one of claims 1 to 15.

5 17. The system of claim 16, further comprising: client interfaces configured to receive manual inputs and report uploads and to render dashboards and reports; an integration gateway configured to interface with wearable-device vendor clouds; and connectors configured to receive measurements from clinical devices and information systems.

10 18. The system of claim 16 or claim 17, wherein the memory further stores a validation module operative to enforce schema conformity and unit harmonisation, a provenance module operative to stamp accepted records with provenance metadata, a normalisation module operative to map raw measurements to a bounded common scale, a sub-scoring module operative to compute domain sub-scores, a dynamic-weighting module operative to select or adapt domain weights with reference to a context vector, a classifier module operative to assign risk classes, a guard-rail
15 module operative to adjust or cap the composite health index in response to sentinel biomarker states, and an outputs module operative to generate dashboards, reports and alerts.

20 19. The system of any one of claims 16 to 18, wherein the memory further stores a consent manager configured to enforce granular data-sharing scopes and a retention manager configured to apply retention and deletion policies.

20. The system of any one of claims 16 to 19, wherein storage is logically or physically isolated on a per-tenant basis and maintains versioned artifacts supporting deterministic recomputation of past results.

21. The system of any one of claims 16 to 20, wherein the dynamic-weighting module is configured to apply constrained updates to weight vectors when sentinel biomarkers cross configured thresholds and to record an adaptation event identifier with the corresponding computation metadata.
- 5 22. The system of any one of claims 16 to 21, wherein the guard-rail module is configured to: (i) apply a cap to the composite health index when cardiovascular sentinel biomarkers indicate elevated risk unless mitigating evidence is present; and/or (ii) apply a penalty to the composite health index when inflammatory sentinel biomarkers exceed configured limits.
- 10 23. A non-transitory computer-readable storage medium storing instructions that, when executed by one or more processors, cause performance of the method of any one of claims 1 to 15.
24. A computer program product comprising program code embodied on a computer-readable medium, the program code configured, when executed by one or more
- 15 processors, to implement the system of any one of claims 16 to 22.
25. Use of the method of any one of claims 1 to 15 for producing a composite health index on a bounded scale and classifying the composite health index into risk classes for presentation on a user dashboard or clinician report together with associated computation metadata.
- 20 26. A data record generated by the method of any one of claims 1 to 15, the data record comprising: the composite health index; the assigned risk class; identifiers of the normalisation bound-set, shaping profile, domain weight vector and dynamic-weight policy used; any guard-rail adjustment applied; and provenance metadata for the

underlying measurements.

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