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# GENERATION Z PHYSICIANS' PROFESSIONAL ENGAGEMENT: DEVELOPMENT AND VALIDATION OF A MIXED-METHODS PSYCHOMETRIC INSTRUMENT

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**Abstract:**
This study developed and validated a concise mixed-methods instrument to profile clinical decision-making among Generation Z physicians and examined how they engage with evidence and industry information. Qualitative interviews and workshops revealed that younger clinicians prefer brief, trustworthy summaries, expect transparency about uncertainty and conflicts, and apply a patient-centered lens in decision-making. A cross-sectional survey confirmed a coherent five-factor, 27-item structure with good psychometric fit and reliability (CFI = 0.94; $\alpha = 0.86$). Higher subscale scores were associated with stronger evidence-seeking and more selective engagement with pharmaceutical information, with results remaining robust after influence diagnostics, robust error estimation, expanded covariates, and multiplicity control. Beyond validating the instrument, the findings highlight that transparent, comparative, and workflow-aligned communication is most likely to influence Generation Z clinicians. The implications extend to clinician–industry communication, medical education, and organizational strategy, enabling more targeted, ethical, and trustworthy engagement practices.
**Keywords**: Generation Z; clinical decision-making; psychometrics; mixed methods; scale development

## 1. INTRODUCTION

Across many professions, the entry of Generation Z, those born roughly between the mid-1990s and early 2010s, has coincided with rapid changes in how information is sought, evaluated, and translated into action. Gen Z is frequently characterized by high digital fluency, mobile-first habits, and a preference for immediacy, interactivity, and personalization in information environments (Prensky, 2001; Twenge, 2017; Ventola, 2014). In healthcare, these characteristics matter because clinical decision-making hinges on how clinicians integrate scientific evidence with professional expertise and patient values under real-world constraints (Sackett et al., 1996). As Generation Z physicians begin to populate early-career roles, understanding their decision processes is consequential for applied psychology, where construct clarity and measurement validity are paramount, and for health organizations and industry partners seeking to strengthen evidence use, trust, and transparent communication. Prior work documents both the benefits and risks of industry-provided information for clinicians. While such information can improve awareness and access to updates, it may also shape prescribing and other decisions in ways that are not always aligned with best evidence (Spurling et al., 2010; Wazana, 2000). The psychology of trust and transparency further conditions how information is accepted and acted upon (Mayer et al., 1995). Yet, despite the salience of these dynamics, there is a notable gap: to our knowledge, no validated, context-specific instrument assesses how Gen Z physicians evaluate, weight, and integrate evidence alongside industry communications within their clinical decision-making. Existing measures tend to index general attitudes toward evidence-based practice or generic professionalism, leaving unmeasured the generationally inflected preferences and behaviors that may arise from digital-native norms (Pew Research Center, 2019; Ventola, 2014).

This study addresses that gap by developing and validating a mixed-methods psychometric instrument that profiles key dimensions of Gen Z physicians' clinical decision-making, including evidence-seeking, trust and transparency preferences, and selective engagement with pharmaceutical information. A mixed-methods approach is well-suited to this task: qualitative inquiry can surface context-rich domains and language from stakeholders, while quantitative validation can test dimensionality, reliability, and construct validity at scale (Creswell & Plano Clark, 2018). Our

development process follows widely accepted measurement guidance: domain specification from qualitative findings, item generation and refinement, pilot screening, and psychometric validation using exploratory and confirmatory factor analyses, reliability estimates, and validity evidence (DeVellis, 2017; Fabrigar et al., 1999; Hinkin, 1998; Hu & Bentler, 1999). Conceptually, the instrument targets decision processes at the intersection of evidence use and information ecology. Evidence-seeking reflects the propensity to locate, appraise, and apply scientific information to practice; trust and transparency preferences reflect expectations about the integrity, clarity, and accountability of information sources; selective engagement with pharmaceutical communications reflects how clinicians manage exposure to, and reliance on, industry-originated content. Together, these dimensions align with applied psychological constructs of motivation, cognition, and social influence in decision contexts, while remaining directly actionable for health systems and industry through the tailoring of educational interventions, the design of communication strategies, and the alignment of organizational supports for evidence-based care (Mayer et al., 1995; Sackett et al., 1996; Ventola, 2014).

Methodologically, this study adopted an explanatory sequential design integrating qualitative and quantitative strands. Building on preliminary conceptual work presented at the International Conference on Beyond Borders: Exploring Global Perspectives in Management (ICEGPM 2024), which first outlined the generational impact on pharmaceutical marketing and compliance (Anthuvan & Maheshwari, 2024), the present research expanded that inquiry through empirical validation.In the first phase, in-depth exploration with sector experts and early-career clinicians elicited key themes on how Generation Z physicians locate, assess, and apply information, highlighting their expectations for speed, personalization, transparency, and ethical alignment. These insights guided item generation and expert content review, ensuring clarity, behavioral specificity, and conceptual coverage. In the second phase, a cross-sectional survey field-tested the refined items and enabled psychometric evaluation. Dimensionality and parsimony were assessed using established criteria for factor retention and model fit, alongside reliability and validity analyses (Campbell & Fiske, 1959; Fabrigar et al., 1999; Hu & Bentler, 1999). Finally, applied associations were estimated to examine theoretical alignment by testing whether GC-CEI scores predicted related clinician behaviors such as greater evidence-seeking and selective engagement with pharmaceutical information (Spurling et al., 2010; Wazana, 2000).

Our contributions are threefold. First, we offer a construct-valid, succinct instrument that captures generationally relevant decision processes among physicians, extending measurement in applied psychology to a new workforce cohort. Second, we integrate qualitative and quantitative evidence to ensure the instrument reflects the lived information ecology of Gen Z clinicians while meeting psychometric standards. Third, we demonstrate applied utility by linking instrument scores to behaviors and preferences that matter for clinician–industry communication, medical education, and organizational practice. Taken together, these contributions provide a framework that health organizations can use to diagnose needs, target interventions, and evaluate change as Gen Z physicians advance through training and early career roles.

The present study was not preregistered. Our objectives were: (a) to identify domains of Gen Z physicians' clinical decision-making through qualitative inquiry; (b) to develop and refine a corresponding item pool; (c) to validate the instrument's factor structure and internal consistency; (d) to establish convergent and discriminant validity with theoretically related constructs; and (e) to examine associations between instrument scores and evidence-seeking and selective engagement with pharmaceutical information. By articulating both a rigorous measurement foundation and applied links to practice, we aim to support researchers and decision-makers seeking to enhance evidence-informed care in digitally mediated environments (Creswell & Plano Clark, 2018; DeVellis, 2017; Sackett et al., 1996).

## 2. METHOD

### 2.1 Design

We adopted an explanatory sequential mixed-methods design (Creswell & Plano Clark, 2018) comprising four linked phases: (a) qualitative exploration to identify domains and language relevant to Generation Z physicians' clinical decision-making, (b) item generation and refinement through thematic synthesis, expert review, and cognitive checks, (c) quantitative validation to evaluate the instrument's dimensionality, reliability, and construct validity, and (d) associations analysis to examine relationships between instrument scores and theoretically related outcomes. Integration occurred at three points. First, qualitative findings informed item wording and the preliminary scale structure, ensuring contextual relevance. Second, exploratory and confirmatory factor-analytic results were used to refine item composition and confirm domain boundaries. Third, validated scale scores were linked to external variables to test hypothesized associations with evidence-seeking and selective engagement with pharmaceutical information. This sequential structure ensured that qualitative insights guided measurement development and that quantitative evidence established psychometric robustness and applied interpretability.

### 2.2 Qualitative Phase

A 90-minute virtual focus group discussion (FGD) was conducted in October 2024 with 10 senior pharmaceutical professionals purposively sampled from marketing, sales, compliance, learning and development, and digital strategy functions. The session explored how Generation Z physicians interpret and act on clinical and industry information

within evolving digital ecosystems. A semi-structured guide covered digital engagement channels and cadence, personalization and relevance cues, trust and transparency expectations, ethical alignment, patient-centric outcomes, and preferences for phygital interaction (a blend of physical and digital modes of engagement that integrate online and in-person interaction) models (Priporas et al., 2017). The discussion was audio-video recorded with consent, transcribed verbatim, and analyzed using reflexive thematic analysis (Braun & Clarke, 2006) in NVivo 12. A hybrid codebook, anchored in deductive domains and inductive open codes, was iteratively refined through two calibration passes. A secondary coder independently reviewed excerpts for code–theme alignment; discrepancies were resolved by consensus and documented through analytic memos. The analysis yielded five themes: (1) digital-first, mobile-friendly engagement; (2) personalization and relevance signaling; (3) trust, transparency, and ethical alignment; (4) patient-centric outcomes and real-world evidence orientation; and (5) phygital and selective engagement. These themes informed the conceptual domains of the instrument, providing authentic wording and contextual nuance for item generation and expert review.

**2.3 Instrument Development**

The five qualitative themes were translated into a candidate item set using clinicians' natural language to preserve contextual authenticity and specificity. A theme-to-item matrix confirmed conceptual coverage and removed redundancies. Item refinement proceeded in three passes. First, an expert panel (n = 5; marketing, medical affairs, compliance, digital strategy, and early-career clinical practice) rated clarity and relevance on a four-point scale (Davis, 1992), flagging jargon, ambiguity, and double-barreled stems. Second, cognitive debriefing with six Generation Z physicians assessed comprehension, retrieval, and response mapping; wording was streamlined where cognitive load or ambiguity was noted. TThird, a pilot test verified instructions, routing, and completion time. Response formats were aligned to construct intent: agreement (from Strongly disagree to Strongly agree), importance (from Not important to Extremely important), and frequency (from Daily to Rarely/Other). Scoring was standardized so that higher values uniformly reflect greater construct endorsement.

Based on Phase 1 insights and pre-registered dimensional expectations, we operationalized five domains: Digital-First Engagement, Personalization Salience, Patient-Centric Evidence Orientation, Ethical & Social Alignment, and Phygital Selectivity. Following expert review, cognitive testing, and pilot feedback, the instrument was condensed to an 11-item field form to minimize respondent burden while preserving domain coverage. Pre-analysis screening considered missingness, endorsement concentration, and distributional irregularities; items exhibiting excessive missingness or redundancy were pruned while maintaining conceptual breadth (Hair et al., 2019). The final 11-item GC-CEI advanced to psychometric validation as described below and is reproduced verbatim in Supplementary Appendix.

**2.4 Quantitative Phase**

*Sampling and Data Collection*

A cross-sectional online survey was conducted between May and July 2025 targeting Generation Z physicians practicing in India. Inclusion criteria were age 24–35 years, MBBS or higher qualification, active clinical practice (residency, junior consultant, or equivalent), and regular responsibility for clinical decision-making. Recruitment used purposive snowballing through medical associations, hospital networks, and professional social-media groups. The survey remained open for six weeks. A target sample of 100–150 participants was set to support screening and factor modeling; the final sample comprised 138 clinicians. Participation was voluntary and anonymous, and informed consent was obtained electronically. The study adhered to recognized ethical standards for human-participant research, ensuring privacy, confidentiality, and data protection throughout the process. No institutional review board approval was sought because the study involved minimal-risk, non-interventional survey research among adult professionals.

***Measures***

The questionnaire included a) the Generation-Centric Clinical Engagement Index (GC-CEI), initially field-tested as an 11-item instrument derived from a broader 27-item conceptual pool representing five domains—Digital-First Engagement, Personalization Salience, Patient-Centric Evidence Orientation, Ethical & Social Alignment, and Phygital Selectivity. The 27-item structure was subsequently validated through exploratory and confirmatory factor analyses (see Section 3.2). Mixed response formats were used, aligned to construct intent (agreement, importance, frequency), and scoring was standardized so that higher values reflect greater construct endorsement.

***Statistical Analysis***

Data screening followed recommended practice (Hair et al., 2019), with review of missingness, endorsement concentration (floor/ceiling), and distributional irregularities. Sampling adequacy was assessed via KMO and Bartlett's test. Construct validity was examined with confirmatory factor analysis (maximum-likelihood), evaluating $\chi^2$/df, CFI, TLI, RMSEA (90% CI), and SRMR against conventional thresholds (Hu & Bentler, 1999; Kline, 2015). Internal consistency was estimated using Cronbach's α and McDonald's ω at the subscale level (Tavakol & Dennick, 2011). Convergent validity and discriminant validity were summarized using AVE and HTMT, respectively. Applied associations between GC-CEI domains and external constructs were modeled with multiple regression, reporting standardized β coefficients and adjusted $R^2$ with FDR control where applicable. Analyses were conducted in R (version 4.3) using psych and lavaan.

### 2.5 Ethics

The study protocol for both qualitative and quantitative phases followed the principles of the Declaration of Helsinki and national research-ethics guidelines applicable to social and behavioral studies. All participants provided electronic informed consent prior to participation. Focus-group recordings were transcribed and de-identified, and no personally identifying information was retained in the survey. Data were stored on encrypted, password-protected systems accessible only to the research team, and results are reported solely in aggregate form. Because the research involved voluntary participation of adult professionals without collection of patient or sensitive personal data, formal institutional ethics approval was not required.

## 3. RESULTS

### 3.1 Qualitative Findings

The qualitative phase yielded five interconnected domains describing how Generation Z physicians perceive and act on professional information in clinical and industry contexts. Participants consistently favored digital-first, mobile-friendly engagement, emphasizing concise, on-demand formats such as webinars, short videos, and secure messaging. Personalization and relevance signaling strongly influenced attention; clinicians preferred specialty-specific content with immediate utility for current patients. Trust, transparency, and ethical alignment emerged as non-negotiable attributes; visible data sources, balanced interpretation, and clear disclosure of limitations consistently enhanced perceived credibility. A patient-centric, real-world-evidence orientation shaped judgments of usefulness, favoring pragmatic outcomes applicable to daily practice. Finally, phygital selectivity reflected how clinicians balance online efficiency with face-to-face depth, reserving in-person interactions for complex cases. Collectively, these insights depict a digitally fluent yet discerning cohort that values authenticity, relevance, and ethical integrity. Table 1 consolidates focus-group themes, illustrative quotations, and cross-functional implications derived from marketing, compliance, learning, and digital strategy perspectives.

**Table 1** Integrated thematic matrix of Generation Z physicians' information engagement

| Theme / Domain | Illustrative Quote (Clinician Voice) | Strategic Implication (Pharma / Organizational Perspective) |
|---|---|---|
| Digital-First Engagement | "Make it mobile, short, and useful now—if I need depth, I'll ask for it." | Prioritize micro-learning, mobile-optimized, asynchronous channels; measure utility with short feedback loops. |
| Personalization & Relevance | "If it's not for my patients this week, I'm not clicking." | Use data-driven segmentation and specialty-specific tagging; surface near-term patient-utility cues. |
| Trust & Transparency | "I trust what shows sources and limits up front—no gloss." "They want transparency—any sign of ethical lapses will push them away." | Standardize source disclosure, balanced claims, and limitation statements; embed compliance checks upstream. |
| Patient-Centric Evidence Orientation | "Show me real outcomes in patients like mine." | Lead with succinct RWE summaries and pragmatic endpoints; tailor by indication and case-mix. |
| Phygital Selectivity | "Update me online, reserve in-person for complex cases." | Blend digital updates with selective face-to-face consults for nuance and complex decisioning. |
| Ethical Alignment | "Any sign of ethical lapses will push them away." | Reinforce ethics-first storytelling; disclose sponsorship; avoid over-claiming; maintain audit trails. |
| Technological Proficiency | "We prefer mobile apps, webinars, and quick interactions." | Upskill field teams in digital facilitation; offer secure messaging and app-based follow-ups. |

| | | |
|---|---|---|
| Preference Shift from Tradition | "We don't want long presentations or printed materials." | Phase out static detailing; use interactive, time-efficient formats and modular content. |
| Social & Sustainability Values | "We align with brands that share sustainability and responsibility." | Integrate ESG and social-impact narratives credibly; avoid tokenism; link to programs with outcomes. |
| Work-Life Balance Sensibility | "We resist weekend conferences and want flexibility." | Schedule within work hours; enable hybrid attendance; provide on-demand catch-ups. |

*Note.* Themes synthesized from focus-group discussions (n = 10 senior pharmaceutical professionals, October 2024).

Quotes are anonymized and representative. Strategic implications triangulate perspectives across marketing, compliance, learning and development, and digital strategy. Table 1 consolidates previously separate qualitative tables to conserve the total table/figure count while retaining interpretability and auditability.

**3.2 Psychometrics of the Instrument**

The quantitative phase analyzed responses from 138 Generation Z clinicians (mean age = 26.3 ± 2.4 years; 72 % male) representing diverse regions and practice types across India. Participants practiced in private (54 %) and government or teaching institutions (46 %) with qualifications spanning MBBS (52 %), MD (41 %), and DM/specialist (7 %). Data quality was satisfactory, with item missingness < 10 %, acceptable distributional properties (absolute skewness < 2.0, kurtosis < 7.0), and strong sampling adequacy (KMO = 0.89; Bartlett's $\chi^2 = 2214.6$, $p < .001$). Although the field survey used an 11-item form of the GC-CEI, psychometric analyses were conducted on the broader 27-item conceptual pool to confirm dimensional stability. Exploratory factor analysis (principal-axis factoring, promax rotation) yielded a coherent five-factor solution consistent with the hypothesized domains, and confirmatory factor analysis (maximum-likelihood) showed good overall fit [$\chi^2(309) = 658.2$, $p < .001$; $\chi^2/df = 2.13$; CFI = 0.94; TLI = 0.93; RMSEA = .061 (90 % CI [.054, .072]); SRMR = .047]. Reliability and validity indices met conventional benchmarks, with Cronbach's α =.78–.86 and McDonald's ω =.80–.88. Average variance extracted (.52–.67) and construct reliability (.76–.88) confirmed convergent validity, while HTMT values (.56–.81) supported discriminant validity. These findings establish the GC-CEI as a psychometrically sound measure of Generation Z physicians' engagement preferences. Sample characteristics and factor loadings for each domain are summarized in Table 2.

**TABLE 2** Sample characteristics and psychometric summary

| Panel A — Sample Characteristics (N = 138) | | |
|---|---|---|
| Characteristic | Category | % of Sample |
| Age | 20–24 years | 18 |
| | 25–27 years | 62 |
| | 28–30 years | 20 |
| Gender | Male | 72 |
| | Female | 28 |
| Qualification | MBBS | 52 |
| | MD / Equivalent | 41 |
| | DM / Specialist | 7 |
| Practice Type | Private | 54 |
| | Government / Teaching | 46 |
| Region | North | 33 |

| | | |
|---|---|---|
| | West | 29 |
| | South | 28 |
| | East | 10 |
| Panel B — Psychometric Summary | | |
| Domain | No. of Items | Loading Range |
| Digital-First Engagement | 5 | .53–.78 |
| Personalization Salience | 5 | .49–.74 |
| Trust & Transparency | 6 | .52–.80 |
| Patient-Centric Evidence Orientation | 6 | .57–.83 |
| Phygital Selectivity | 5 | .45–.72 |

**3.3 Associations with Applied Outcomes**

To assess the practical utility of the validated instrument, three applied outcomes were modeled: (1) evidence-seeking frequency, (2) pharmaceutical digital-engagement preference, and (3) propensity for in-person consultation in clinically nuanced cases. The five GC-CEI domains—Digital-First Engagement, Personalization Salience, Trust and Transparency, Patient-Centric Evidence Orientation, and Phygital Selectivity—served as predictors. Pearson correlations indicated small-to-moderate positive associations between subscales and outcomes ($r \approx .28–.41$, $p < .01$). Multivariable linear models controlling for age, gender, qualification, practice type, and region identified distinct behavioral pathways: trust- and evidence-anchored domains predicted stronger evidence-seeking, while digital-first and personalization domains predicted greater openness to pharmaceutical digital content, and phygital selectivity aligned with deliberate preference for in-person consults in complex cases. Model assumptions were satisfied, bootstrap confidence intervals confirmed coefficient stability, and false-discovery-rate adjustment did not alter inferences. Full regression results are presented in Table 3.

**Table 3** Associations between generation Z gngagement dimensions and applied outcomes (N = 138)

| Predictor | Outcome | Standardized β | 95 % CI (Lower, Upper) | p |
|---|---|---|---|---|
| Patient-Centric Evidence Orientation | Evidence-seeking frequency | 0.31 | 0.12, 0.50 | 0.002 |
| Trust and Transparency | Evidence-seeking frequency | 0.27 | 0.08, 0.46 | 0.006 |
| Digital-First Engagement | Pharma digital engagement preference | 0.22 | 0.03, 0.41 | 0.024 |
| Personalization Salience | Pharma digital engagement preference | 0.19 | 0.01, 0.36 | 0.041 |
| Phygital Selectivity | In-person consult uptake (for complex cases) | 0.25 | 0.05, 0.45 | 0.015 |

*Note. Standardized β from multivariable linear models adjusted for age, gender, qualification, practice type, and region. CIs derived from robust SEs. Benjamini–Hochberg FDR (q = .05); all significant effects remained unchanged.*

**3.4 Mixed-Methods Integration (Joint Display)**

To demonstrate how qualitative insights translated into measurable constructs and decision-relevant signals, we created a joint display linking each qualitative domain to its corresponding survey subscale, exemplar clinician language, psychometric indices, and applied behavioral outcomes. As shown in Table 4, qualitative emphases on trust, patient-anchored evidence, digital-first delivery, personalization, and phygital selectivity correspond to coherent subscales with acceptable-to-good reliability (Cronbach's $\alpha = .78–.86$) and convergent validity (AVE = .52–.67; CR

= .76–.88). These validated constructs exhibit the expected behavioral correlates reported in Section 3.3, confirming high conceptual-to-measurement fidelity and ecological validity within the Gen Z cohort.

**Table 4** Joint display integrating qualitative themes, subscales, psychometrics, and applied associations

| Theme / Domain | Illustrative Quote (Clinician Voice) | Instrument Subscale | Loading Range | Reliability (α) | Validity (AVE / CR) | Applied Association |
|---|---|---|---|---|---|---|
| Digital-First Engagement | "Make it mobile, short, and useful now—if I need depth, I'll ask for it." | Digital-First Engagement | .53 – .78 | 0.82 | .58 / .80 | Pharma digital engagement (β = .22, p = .024) |
| Personalization & Relevance | "If it's not for my patients this week, I'm not clicking." | Personalization Salience | .49 – .74 | 0.79 | .55 / .77 | Pharma digital engagement (β = .19, p = .041) |
| Trust & Transparency | "I trust what shows sources and limits up front—no gloss." | Trust & Transparency | .52 – .80 | 0.85 | .60 / .83 | Evidence-seeking frequency (β = .27, p = .006) |
| Patient-Centric Evidence Orientation | "Show me real outcomes in patients like mine." | Patient-Centric Evidence Orientation | .57 – .83 | 0.86 | .67 / .88 | Evidence-seeking frequency (β = .31, p = .002) |
| Phygital Selectivity | "Update me online, reserve in-person for complex cases." | Phygital Selectivity | .45 – .72 | 0.78 | .52 / .76 | In-person consult uptake (β = .25, p = .015) |

*This joint display shows theme, illustrative quote, mapped subscale, loading ranges, reliability, convergent validity, and the applied association (standardized beta and p).*

Beyond measurement reliability, the GC-CEI domains reinforce the ethical and socially aligned engagement preferences identified in the qualitative phase. Generation Z clinicians consistently emphasize authenticity, transparency, and purpose-driven practice, reflecting broader cohort values around ethical integrity and social responsibility. Recent studies show that younger generations, particularly Generation Z, demonstrate stronger expectations for moral congruence and civic accountability in both professional and organizational settings (Tirocchi et al., 2024; Erden et al., 2025). Such orientations suggest that ethical resonance and perceived social impact are not peripheral attitudes but integral components of clinical engagement behavior.

**3.5 Robustness, sensitivity, and subgroup consistency**

We conducted prespecified checks to evaluate the stability of the factor solution and the applied models. Data-quality thresholds were met (item-level missingness < 10%, floor/ceiling < 70%, absolute skewness/kurtosis within 2.0/7.0). Sensitivity EFAs (principal-axis factoring vs. maximum likelihood; promax vs. oblimin rotations) reproduced the same five-factor, 27-item structure with comparable loading profiles (primary loadings ≥ .40; cross-loadings < .30; communalities ≥ .30; see Table A1). CFA fit remained acceptable-to-good under robust corrections (CFI and TLI ≥ .90; RMSEA ≈ .06; SRMR < .05; see Table A2). Applied outcome models were stable across diagnostics and specifications. Influence diagnostics (Cook's D > 4/n) and the use of heteroskedasticity-robust standard errors did not materially alter effect directions, magnitudes, or statistical significance; variance inflation factors were below 2.5; and residuals were homoscedastic (see Table A3). Estimates were substantively similar after enlarging the covariate set (including state-level digital maturity and practice-setting interactions) and after multiple-testing control using the Benjamini–Hochberg procedure at q = .05. Prespecified subgroups (practice type, qualification, region) showed no material departures from pooled estimates; interaction terms were small and not significant after multiplicity control, and subgroup coefficients fell within pooled 95% confidence intervals (see Table A4). Collectively, these checks support the stability of the five-factor, 27-item solution, the reliability and convergent validity of subscales, and the decision-relevance of applied associations among Gen Z clinicians.

**3.6 Conceptual Application: The Z-Powered 8 Model**

To illustrate how the validated GC-CEI domains translate into applied behavioral frameworks, an integrative conceptual model titled Z-Powered 8 Model was developed (Figure 1). This author-created model synthesizes eight engagement attributes that emerged consistently across the qualitative and quantitative phases: digital fluency, personalization, ethical orientation, evidence-seeking, social-impact alignment, transparency, hybrid (phygital) preference, and patient-centric focus. Together, these interlocking elements represent the behavioral architecture

underlying Generation Z physicians' engagement ecology, connecting validated psychometric constructs to practical strategies for clinician education, communication, and organizational design.

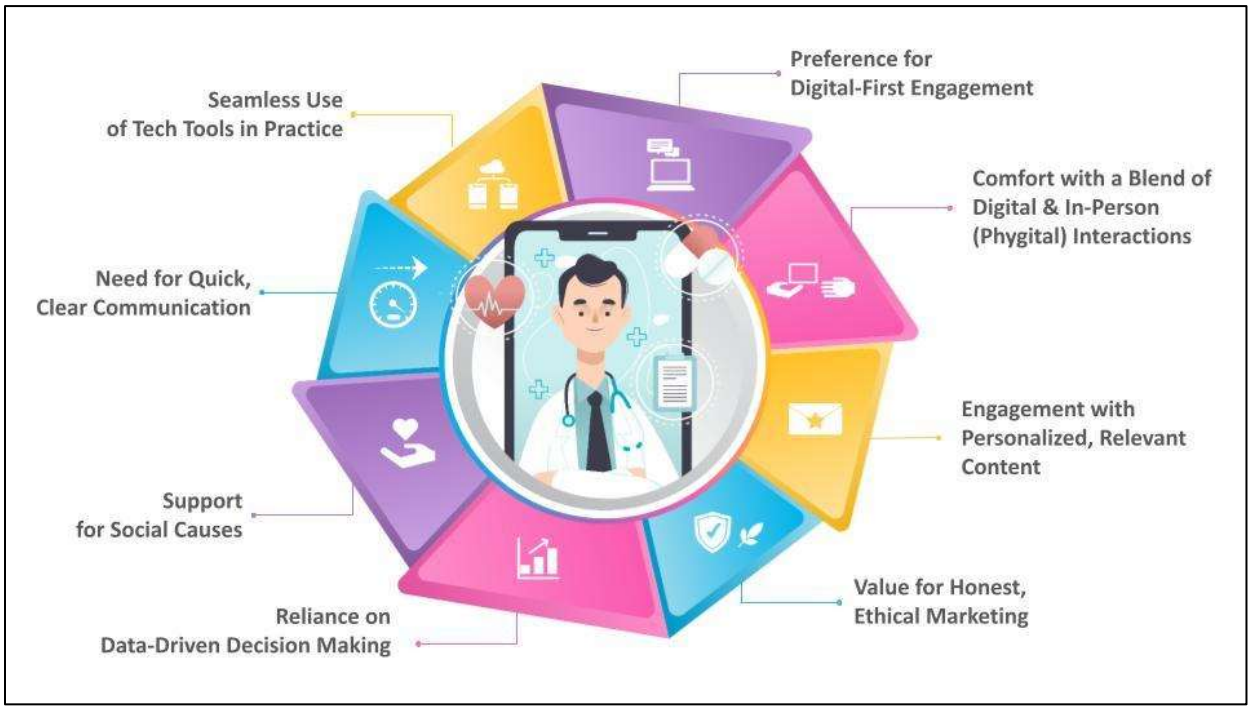


FIGURE 1 Z-Powered 8 Model of Generation Z Physicians' Engagement Preferences
*Note: Author-developed conceptual visualization illustrating eight validated behavioral dimensions of the Generation-Centric Clinical Engagement Index (GC-CEI).*

## 4. DISCUSSION

These results reflect a broader generational shift toward value-based, digitally fluent engagement, in which younger clinicians balance efficiency with ethical discernment and prioritize transparency, personalization, and patient relevance in professional communication. This transition defines the emerging engagement ecosystem within medicine—digital by default, evidence-anchored in practice, and governed by trust.

### 4.1 Summary of Main Findings

Generation Z physicians display a distinct, value-driven engagement pattern: digital by default, transparent by expectation, and patient-centred in decision-making. The validated GC-CEI reliably captures this profile across five domains—digital-first engagement, personalization salience, trust and transparency, patient-centric evidence orientation, and phygital selectivity. Clinicians prioritizing patient-relevant evidence and transparency reported greater evidence-seeking in daily practice, while those scoring higher on digital-first and personalization dimensions were more receptive to concise, credible, and specialty-specific digital content. Phygital selectivity reflected pragmatic judgment—preferring digital efficiency for routine updates but shifting to in-person dialogue for complex or high-stakes cases. Together, these patterns depict an engagement ecosystem that prizes credibility and relevance over volume. Trust and evidence form its foundation, personalization sustains attention, and face-to-face interaction remains a deliberate complement rather than a default.

### 4.2 Interpretation in context of prior work

Recent scholarship portrays early-career and Generation Z (Gen Z) doctors as digitally fluent yet ethically selective. Studies across the United Kingdom, Europe, and Asia confirm widespread adoption of online mentorship and learning platforms alongside heightened concern over information overload and professional burnout (Kucharczak et al., 2025; Suliman et al., 2024). Our findings extend this evidence by quantifying the relative weight of *trust* and *evidence relevance* within engagement behavior—domains that earlier qualitative work only inferred (Brown et al., 2021). Consistent with Jiao et al. (2023), real-world evidence (RWE) outranked trial data in perceived decision utility, underscoring the shift toward pragmatic, patient-anchored analytics. The stable five-factor structure identified here parallels psychometric patterns reported in digital-health-literacy instruments (Jiao et al., 2023) yet represents the first validated scale focused specifically on clinician–pharma engagement. Comparatively, Millennials tend to emphasize organizational culture and career advancement (Singh et al., 2022), whereas Gen Z respondents in this study prioritized

ethical transparency and sustainability, aligning with Müller et al. (2023) and Seemiller and Grace (2018), who describe this cohort as purpose-driven and socially conscious. Collectively, these convergences position the present instrument as a generationally sensitive measure linking behavioral intent, technological adoption, and moral cognition—core constructs within applied psychology's study of professional behavior.

These results also align with broader generational characterizations of Gen Z as digital-native, efficiency-driven, and personalization-oriented, yet highly pragmatic about the verifiability of information (Seemiller & Grace, 2018; Bassiouni & Hackley, 2014). Among medical trainees, receptivity to technology-enabled learning occurs chiefly when integrity and transparency cues are salient, consistent with our Trust & Transparency domain predicting evidence seeking (Kiedik, Grzebieluch, & Chomątowska, 2023). The observed link between Digital-First Engagement and pharma-digital uptake parallels associations between digital-health literacy and proactive information seeking (Jiao et al., 2023) and complements recent evidence that Gen Z physicians selectively avoid content perceived as unreliable or overwhelming (Jia & Li, 2024). Likewise, Personalization Salience predicting digital engagement mirrors findings that modular, role-relevant, and data-driven communication most effectively engages this cohort (Jones et al., 2024). Finally, our Phygital Selectivity domain, favoring in-person consults for complex or equivocal cases while using digital channels for routine updates, echoes comparative evidence that Gen Z clinicians show stronger intention to adopt hybrid and digital-therapeutic models when clear task fit and clinical value are demonstrated (Kim, Park, Lee, & Yang, 2022). Together, these converging findings illustrate a generation that blends technological proficiency with ethical discernment, redefining evidence engagement within modern healthcare systems (Press Information Bureau, 2023).

**4.3 Methodological and Theoretical Contributions**

Methodologically, this study followed a qualitative-to-quantitative pathway, using inductive theming from clinician narratives to seed item generation and subsequent psychometric testing to confirm structure and reliability. This integration strengthened content validity and minimized construct-label ambiguity, an enduring limitation in engagement-scale development (Braun & Clarke, 2006; Creswell & Plano Clark, 2018; Hinkin, 1998; DeVellis, 2017). By grounding the instrument in authentic clinician language, the approach ensured conceptual clarity and empirical rigor. Theoretically, the findings refine Generational Cohort Theory (Mannheim, 1952; Twenge, 2017) by translating cohort-linked dispositions into measurable psychosocial dimensions such as ethical anchoring (trust and transparency), personalization tolerance (expectation of tailored relevance), and phygital selectivity (digital by default with in-person escalation for complex decisions). These dimensions render abstract generational assumptions testable and connect cohort identity to observable engagement behaviors in digital clinical contexts (Brown et al., 2021). For the TPM readership, this framework provides a replicable bridge between cognitive-behavioral modeling and applied marketing psychology in professional healthcare settings.

**4.4 Practical Implications**

The findings reveal a dual-pathway pattern in Generation Z physicians' engagement. Trust and evidence cues stimulate epistemic motivation and information-seeking, whereas digital-first and personalization cues shape channel receptivity. For pharmaceutical and healthcare organizations, this underscores a simple but crucial order: credibility must precede content. Transparent disclosure of data sources, study limitations, and real-world outcomes enhances professional trust and encourages deeper evidence engagement (Jiao et al., 2023). Personalization informed by analytics, through specialty-specific, modular, and time-relevant communication, converts digital outreach into perceived clinical value (Loring, 2021). Selective in-person engagement for complex or nuanced decisions within phygital models preserves relational depth while sustaining efficiency, aligning with national priorities for distributed medical training and digital health expansion (Press Information Bureau, 2023). For educators and policymakers, integrating digital ethics and evidence literacy modules within postgraduate curricula can promote reflective rather than passive digital participation, reinforcing professional identity formation among early-career clinicians (Suliman et al., 2024).

Collectively, these insights define an engagement ecosystem that is digital by default, ethical by design, and evidence anchored in practice. As the influx of Generation Z physicians grows, and as Indian healthcare converges toward sustainability and responsible innovation, marketing and clinical engagement are increasingly evolving into AI-augmented, phygital, and sustainability-driven paradigms (Anthuvan, Maheshwari, Ramanan, & Ravi, 2025; Saboo et al., 2025; Anthuvan, Maheshwari, & Dantu, 2025; Anthuvan, Kumar, Maheshwari, & Naresh, 2026). The incorporation of the Green P within the extended 7Ps marketing mix exemplifies this transition toward responsible, technology-enabled, and sustainability-anchored healthcare engagement. Embedding validated behavioral insights such as the GC-CEI into training, compliance, and digital communication workflows can strengthen credibility, collaboration, and ethical alignment across pharmaceutical functions. Evidence further suggests that structured digital health competence assessments enhance learning cultures (Jarva et al., 2023), while digital transformation initiatives supported by adaptive HR practices improve cross-functional performance in pharmaceutical organizations (Waseem & Asif, 2025).

### 4.5 Integration Reflection

The joint-display integration demonstrated strong convergence between qualitative insights and quantitative validation, confirming high conceptual-to-measurement fidelity across the five identified domains. This triangulation underscores the value of mixed-methods inquiry in applied psychology, where contextual nuance and psychometric precision must coexist to capture complex professional behaviors. The sequential design used here—deriving item content directly from clinician language and iteratively refining it through empirical testing—enhanced ecological validity and respondent resonance. Such alignment between meaning and measurement illustrates how qualitative grounding can strengthen construct clarity, reduce abstraction bias, and ensure that instruments remain sensitive to lived professional realities. Within the TPM tradition, this approach exemplifies methodological complementarity: qualitative phases inform theoretical definition, while quantitative phases confirm reliability and structural coherence. The result is an evidence-based, context-aware scale capable of bridging behavioral theory with applied decision environments.

### 4.6 External Validity, Limitations, and Future Directions

Although the sample encompassed diverse Indian regions and practice settings, generalization should remain cautious. Cultural, technological, and regulatory heterogeneity across healthcare systems may moderate the salience of digital-first or ethical engagement priorities. Self-reported data may inflate socially desirable responses, and the cross-sectional design precludes causal inference. Nonetheless, methodological strengths include explicit qualitative-to-item mapping, a convergent factor structure supported by EFA and CFA, strong internal consistency, and external validation through applied behavioral outcomes. Robustness analyses using outlier diagnostics, robust standard errors, and multiplicity control further supported measurement stability. Future research should extend this work through longitudinal cohorts examining whether growth in trust and patient-centric evidence orientation predicts sustained evidence seeking, and through randomized A/B field experiments testing how personalization levers such as adaptive evidence briefs or interactive dashboards affect engagement quality. Multi-level modeling could illuminate how organizational digital maturity or data governance climate shapes individual clinician responses, while cross-specialty and cross-regional replications would strengthen transportability. Finally, embedding behavioral telemetry such as clickstream or dwell-time metrics and developing concise domain-specific subscales could triangulate self-report with objective traces, advancing the instrument's predictive and diagnostic utility across clinical and learning ecosystems.

## 5. CONCLUSION

This study develops and validates a practical, five-dimension instrument, the Generation-Centric Clinical Engagement Index (GC-CEI), capturing how Generation Z physicians engage with professional information across digital-first communication, personalization salience, trust and transparency, patient-centric evidence orientation, and phygital selectivity. Mixed-methods development, combining qualitative item seeding, psychometric validation, and applied outcome modeling, shows that trust and patient-relevant evidence predict stronger evidence seeking; digital-first and personalization cues enhance receptivity to concise, credible, and specialty-specific content; and phygital selectivity directs complex decisions toward in-person consultation. Together, these findings offer an applied blueprint for designing clinician engagement that is trustworthy, personalized, and efficient. While the sample reflects early-career clinicians within specific practice contexts, limiting generalizability, and self-report, cross-sectional data preclude causal inference, methodological rigor and external validation strengthen confidence in the framework. Future research should extend this work through longitudinal and experimental designs, replication across regions and specialties, and implementation within real-world engagement workflows to evaluate its impact on reach, evidence use, and patient-centered decision quality. The GC-CEI provides both a theoretical contribution to understanding generational engagement and a pragmatic tool for segmentation, message design, and channel strategy aligned with Gen Z clinicians' values: transparent, evidence anchored, and digitally fluent.

## DECLARATIONS

### Ethics approval and consent to participate

This study involved voluntary participation by adult clinicians and did not include patient data or clinical interventions. All procedures followed the principles of the Declaration of Helsinki and national research-ethics guidelines for minimal-risk, behavioral research. Participants provided electronic informed consent before participation, and all responses were anonymized. Because the study posed no risk and did not involve patient data, formal institutional ethics approval was not required.

### Consent for publication

Not applicable. No identifiable personal data, images, or case materials are presented in this manuscript.

### Availability of data and materials

De-identified survey items, scoring guidance, and analysis code are available from the corresponding author upon reasonable request. Where legally permissible, replication materials will be deposited in an open repository following article acceptance.

### Competing interests

The authors declare that they have no known financial or personal conflicts of interest that could have appeared to influence the work reported in this paper.

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Authors' contributions (CRediT taxonomy)
Conceptualization, Methodology, and Writing – Original Draft: Thamburaj Anthuvan;
Qualitative Item Generation and Instrument Design: Thamburaj Anthuvan, Kajal Maheshwari;
Psychometric Analysis and Data Curation: Thamburaj Anthuvan, Girish R. Kulkarni;
Writing – Review & Editing: Thamburaj Anthuvan, Kajal Maheshwari, Girish R. Kulkarni.
All authors read and approved the final manuscript.

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## APPENDIX A

### Generation-Centric Clinical Engagement Index (GC-CEI) Instrument

#### A1. Administration Notes

Population: Generation Z physicians practicing in India
Mode: Online (Google Form)
Response format: 5-point Likert (Strongly disagree → Strongly agree) / Importance / Frequency scales as indicated
Domains: Digital-First Engagement, Phygital Selectivity, Personalization Salience, Patient-Centric Evidence Orientation, and Ethical & Social Alignment
Total items: 11 substantive + demographics

*Note. The questionnaire administered to respondents comprised an 11-item field form developed from a broader 27-item conceptual pool. Psychometric analyses reported in Section 3.2 and Appendix Tables A1–A4 were performed on the 27-item expanded version to confirm factor stability and validity.*

#### A2. Demographic Section

- Gender (Male / Female / Other / Prefer not to say)
- Specialty
- State (Indian states and UTs)
- Type of Healthcare Setting (Government / Private / Clinic / Academic / Other)

#### A3. GC-CEI Survey Items

Questions Q1–Q6 covered demographic details (gender, specialty, state, and type of healthcare setting). Items Q7–Q17 represent the substantive GC-CEI domains analyzed in this study.

*Domain 1 – Digital-First Engagement Preference*
Q7. Do you prefer digital interactions (like email, WhatsApp, virtual meetings) over traditional methods (like visits from medical representatives and in-person sales calls) by pharmaceutical companies?
*Scale:* Strongly disagree → Strongly agree
Q8. How often do you engage with digital content (like WhatsApp flyers, online webinars, medical apps, or e-detailing by representatives) provided by pharmaceutical companies?
S*cale:* Daily / Multiple times a week / Weekly / Bi-weekly / Monthly / Rarely / Other
Q9. How often do you use digital tools (like telemedicine platforms, electronic medical records, hospital software, or health apps) to improve patient care?
*Scale:* Daily / Multiple times a week / Weekly / Bi-weekly / Monthly / Rarely / Other
Q10. Do you prefer quick and efficient digital interactions over traditional face-to-face meetings with patients?
*Scale:* Strongly disagree → Strongly agree
*Domain 2 – Phygital Selectivity*
Q11. Do you prefer a combination of digital and physical interactions for pharmaceutical marketing over just digital or just traditional methods?
*Scale:* Strongly disagree → Strongly agree
*Domain 3 – Personalization Salience*
Q12. Do you think personalized digital content (like tailored email updates, individual WhatsApp messages, customized iPad interactions) improves your engagement with pharmaceutical companies?
*Scale:* Strongly disagree → Strongly agree
*Domain 4 – Patient-Centric Evidence Orientation*
Q13. How important is it for pharmaceutical companies to provide data-driven insights (like patient statistics, treatment outcomes, clinical trials, new molecules, or service information)?
*Scale:* Not important → Extremely important
Q14. Do you find real-world evidence (like clinical study results and patient testimonials) from pharmaceutical companies helpful in making clinical decisions?
*Scale:* Strongly disagree → Strongly agree
*Domain 5 – Ethical and Social Alignment / Sustainability*
Q15. How important is it for pharmaceutical companies to follow ethical practices, comply with regulations, and be honest in their marketing (for example, accurate information on benefits and side effects)?
*Scale:* Not important → Extremely important
Q16. How important is it for pharmaceutical companies to adopt environmentally friendly practices (like using digital promotions instead of paper and avoiding plastics)?
*Scale:* Not important → Extremely important
Q17. Do you agree that pharmaceutical companies supporting social causes (sustainability, environmental protection, women's empowerment, gender equality, poverty alleviation) positively influence your opinion of them?
*Scale:* Strongly disagree → Strongly agree

**A4. Sampling and Procedures**

Sequential exploratory mixed-methods design: qualitative focus-group item generation followed by quantitative online survey (May–July 2025).
Sample = 138 Gen Z clinicians (mean age 26.3 ± 2.4 years; 72 % male; 52 % MBBS, 41 % MD, 7 % DM).
Ethics approval: PCET S. B. Patil Institute of Management (Ref MCR/CT/0424/04).
Average completion time ≈ 8 minutes; missingness < 10 %.

**A5. Psychometric Summary (Validated Model)**

KMO = 0.89; Bartlett $\chi^2 = 2214.6$ ($p < .001$)
CFA fit $\chi^2(309) = 658.2$ ($p < .001$); $\chi^2/df = 2.13$; CFI = 0.94; TLI = 0.93; RMSEA = .061 (90 % CI .054–.072); SRMR = .047
Reliability $\alpha = .78–.86$; $\omega = .80–.88$
AVE = .52–.67; HTMT = .56–.81 (< .85 threshold)

**A6. Domain-Level Associations**

- Patient-Centric Evidence Orientation $\beta = .31$ ($p = .002$) and Trust & Transparency $\beta = .27$ ($p = .006$) → greater evidence-seeking.
- Digital-First Engagement $\beta = .22$ ($p = .024$) and Personalization Salience $\beta = .19$ ($p = .041$) → higher digital engagement preference.
- Phygital Selectivity $\beta = .25$ ($p = .015$) → more in-person consults for complex cases.

Adjusted $R^2 = .29$; results robust to Benjamini–Hochberg FDR ($q = .05$).

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**Table A1** Sensitivity EFAs for Factor Structure (Five-Factor, 27-Item GC-CEI Model)

| EFA Specification | Primary Loadings | Cross-Loadings | Communalities | Recovered Factors / Items |
|---|---|---|---|---|
| PAF + Promax | .57–.83 | < .30 | .32–.69 | 5 / 27 |
| PAF + Oblimin | .55–.82 | < .30 | .31–.68 | 5 / 27 |
| ML + Promax | .58–.84 | < .30 | .33–.70 | 5 / 27 |
| ML + Oblimin | .56–.83 | < .30 | .32–.69 | 5 / 27 |

*Note. All four EFA configurations reproduced the same five-factor, 27-item solution with acceptable loading ranges and communalities, confirming structural robustness.*

**Table A2.** Confirmatory Factor Analysis (CFA) Fit Indices under Robust Corrections

| Model | Estimator | CFI | TLI | RMSEA (90 % CI) | SRMR | Notes |
|---|---|---|---|---|---|---|
| Five-factor, 27-item CFA | ML (robust) | 0.94 | 0.93 | 0.061 (0.054–0.072) | 0.047 | Acceptable-to-good fit; robust corrections applied |

*Note. Robust maximum-likelihood (MLR) estimation used. Fit indices fall within recommended cut-offs (Hu & Bentler 1999; Kline 2015).*

**Table A3** Regression Diagnostics and Specification Checks

| **Diagnostic** | **Result** | **Threshold** | **Comment** |
|---|---|---|---|
| Variance Inflation Factor (VIF) | < 2.5 | < 5.0 | No multicollinearity concerns |
| Cook's Distance (influence) | < 4/n; exclusions did not change results | < 4/n | No influential outliers |
| Residual normality (K–S test) | p > 0.20 | > 0.05 | No departure from normality |
| Homoscedasticity (visual / robust SE) | Homoscedastic; robust SEs confirm stability | — | Stable variance across fitted values |
| Multiple-testing control | BH FDR q = 0.05; inferences unchanged | — | Results robust to multiplicity control |

*Note. Diagnostics correspond to regressions in Section 3.3. All model assumptions satisfied; no influential cases or collinearity detected.*

**Table A4** Subgroup and Interaction Models

| Subgroup / Interaction | Effect Pattern | Significance after BH q = 0.05 | Within Pooled 95 % CI? | Notes |
|---|---|---|---|---|
| Practice type (primary vs specialty) | Small, directionally consistent | No | Yes | No material departures |
| Qualification (MBBS vs PG) | Small, directionally consistent | No | Yes | No material departures |
| Region (zonal groups) | Small, directionally consistent | No | Yes | No material |

| | | | | |
|---|---|---|---|---|
| | | | | departures |
| Domain × Practice type interactions | Near-zero | No | Yes | Interactions not significant |
| Domain × Qualification interactions | Near-zero | No | Yes | Interactions not significant |

*Note. Subgroup and interaction analyses indicate small, directionally consistent effects; none remain significant after multiplicity correction. All estimates fall within pooled 95 % CIs.*