**ORIGINAL RESEARCH ARTICLE**

# Unhealthy commodities and pregnant consumers: Analysis based on 4C framework with teaching strategies for higher education marketing students

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## Abstract

Pregnant women are particularly vulnerable due to biological sensitivity and intergenerational consequences, yet little is known about how digital marketing, product availability, and regulation jointly shape their exposure. This study examines how unhealthy commodities are marketed and consumed during pregnancy and how policy tools can be adapted across product categories and jurisdictions to reduce maternal risk. Guided by the Maternal 4C framework—focusing on consumer behavior, content exposure, commodity characteristics, and contextual governance—the analysis employed a qualitative design. It drew on semi-structured interviews with 37 pregnant women in hospital outpatient settings, plus interviews with healthcare providers, regulators, platform and retail actors, and public health advocates. Data were analyzed using the Framework Method with abductive reasoning. Findings reveal that perceptions of safety and necessity among pregnant women are heavily influenced by persuasive narratives, influencer promotion, and algorithmic recommendations that normalize unhealthy products as convenient or acceptable. Ultra-processed foods and sugary drinks often substitute healthier options amid time, fatigue, or financial constraints, while discrepancies between clinical advice and market messages erode risk awareness. The study develops an integrative governance framework and a cross-jurisdictional strategy model that combine fiscal measures, supply-side regulation, pregnancy-specific warnings, marketing controls, and digital platform interventions. Together, these contributions deepen theoretical understanding of the commercial determinants of maternal health and provide practical guidance for coordinated policy, platform governance, and responsible marketing education aligned with the Sustainable Development Goals. *(Afr J Reprod Health 2026; 30 [7]: 92-114).*

**Keywords:** Distribution; Attraction; Commoditis; Chemicals; 4Cs; Public Health

## Résumé

Les femmes enceintes sont particulièrement vulnérables en raison de leur sensibilité biologique et des conséquences intergénérationnelles, pourtant peu est connu sur la manière dont le marketing numérique, la disponibilité des produits et la réglementation façonnent conjointement leur exposition. Cette étude examine comment les produits malsains sont commercialisés et consommés pendant la grossesse, et comment les outils politiques peuvent être adaptés à travers les catégories de produits et les juridictions pour réduire les risques maternels. L'analyse est guidée par le cadre Maternal 4C, centré sur le comportement du consommateur, l'exposition au contenu, les caractéristiques des produits et la gouvernance contextuelle. Une conception qualitative a été utilisée, s'appuyant sur des entretiens semi-structurés avec 37 femmes enceintes en consultations externes hospitalières, et des entretiens supplémentaires avec des prestataires de soins, régulateurs, acteurs des plateformes et du commerce de détail, et défenseurs de la santé publique. Les données ont été analysées par la méthode Framework avec raisonnement abductif. Les résultats montrent que les perceptions de sécurité et de nécessité chez les femmes enceintes sont fortement influencées par des récits persuasifs, la promotion par influenceurs et les recommandations algorithmiques qui normalisent les produits malsains comme pratiques ou acceptables. Les aliments ultra-transformés et boissons sucrées remplacent souvent les options saines sous contraintes de temps, fatigue ou finances, tandis que les écarts entre conseils cliniques et messages marchands affaiblissent la conscience des risques. L'étude développe un cadre de gouvernance intégratif ainsi qu'un modèle stratégique interjuridictionnel combinant des mesures fiscales, une régulation de l'offre, des avertissements spécifiques à la grossesse, des contrôles en matière de marketing et des interventions des plateformes numériques. Ensemble, ces contributions approfondissent la compréhension théorique des déterminants commerciaux de la santé maternelle et fournissent des orientations pratiques pour une action coordonnée en matière

de politiques publiques, de gouvernance des plateformes et de formation en marketing responsable, en cohérence avec les Objectifs de développement durable. *(Afr J Reprod Health 2026; 30 [7]: 92-114).*

**Mots-clés**: Distribution; Attraction; Commodités; Produits chimiques; 4Cs; Santé publique

# Introduction

Recent reforms in higher education have placed growing emphasis on aligning business and marketing education with sustainability agendas and the Sustainable Development Goals, particularly in relation to health and consumer protection. In this context, the marketing of unhealthy commodities to pregnant women offers a critical teaching case for helping marketing students recognize commercial determinants of health and reflect on responsible marketing strategies. Unhealthy commodities refer to marketed products that possess high consumer appeal yet impose systemic harms on health and wellbeing [1]. These include tobacco, alcohol, psychoactive substances, commercial gambling, and highly processed food products, particularly sugar sweetened beverages and ultra-processed foods (UPFs) [2]. Such commodities share several defining characteristics: they are industrially formulated with chemical additives, exhibit hyper palatability, bear weak resemblance to natural foods, and rely heavily on intensive marketing and sophisticated packaging to maximize market penetration [3].

Compared with the general population, pregnant women face elevated risks due to both the biological vulnerability of fetal development and the intergenerational consequences of exposure. Empirical evidence and clinical guidelines consistently highlight the following risks: alcohol use during pregnancy contributes to fetal alcohol spectrum disorders[4]; smoking increases the likelihood of preterm birth and low birth weight[5]; excessive caffeine intake raises the risks of miscarriage and intrauterine growth restriction[6]; consumption of UPFs is linked to gestational diabetes mellitus (GDM) and preeclampsia (PE)[7]; and gambling related psychological and financial stress can undermine prenatal care behaviors[8]. These findings, summarized in recent evidence based reviews, align closely with the objectives and standards established by international health agencies.Within the platform of retail and algorithm driven marketing ecosystem, health oriented narratives such as “natural,” “low sugar,” or “pregnancy safe,” combined with influencer endorsements, further attenuate pregnant women’s risk perception and avoidance intentions, thereby amplifying consumer side externalities. Consequently, integrating maternal populations into the core arena of unhealthy commodity governance is both necessary and strategic. This approach not only advances SDG 3 (Good Health and Wellbeing), specifically its targets related to maternal and child health, non-communicable diseases, and substance dependence, but also intersects with SDG 2 (Nutrition), SDG 5 (Gender Equality and Health Autonomy), and SDG 12 (Responsible Consumption and Production).

Accordingly, this paper proposes a scenario based approach for cross commodity and cross jurisdictional policy transfer, utilizing a combination of interventions such as pricing and taxation mechanisms (e.g., minimum unit pricing), supply side regulation (e.g., retail licensing, density controls, and online sales blocking), product and information governance (e.g., prominent pregnancy specific warnings, packaging and advertising restrictions), platform governance (e.g., targeted marketing restrictions, disclosure mandates, and algorithmic down ranking). Situated within the Maternal 4C framework, comprising consumer, content, commodity, and context, these integrated interventions aim to systematically reduce pregnant women’s exposure and susceptibility to unhealthy commodities and, at the same time, serve as a pedagogical scaffold for curriculum reform in higher education marketing programs, fostering students’ understanding of commercial determinants of maternal health and their capacity for responsible marketing aligned with the Sustainable Development Goals.

## *Literature review*

### *Unhealthy commodities and pregnant consumers: Conceptualization, risk spectrum, and state of the evidence*

In public health research, unhealthy commodities generally refer to market based products that are highly attractive to consumers yet are strongly associated with a range of adverse health outcomes [2]. Within this category, food products, especially ultra-processed foods (UPFs) have attracted particular attention [9]. UPFs are typically characterized by industrial formulations that combine multiple food additives and chemically modified ingredients, and they are designed to maximize palatability, convenience, and market availability [10]. Compared with non- pregnant women, pregnant consumers are doubly distinctive in terms of biological vulnerability and intergenerational impact: the nutritional and non-nutritional components they ingest not only affect maternal metabolic homeostasis, but also influence fetal growth and organ development via placental transfer and endocrine signaling [11, 12]. Accordingly, consumption of UPFs and other potentially teratogenic or development disrupting substances (such as caffeine, alcohol, and certain medications) during pregnancy entails heightened negative externalities and has become a central concern in maternal and child health governance [13, 14].

Current evidence indicates clinically relevant associations between UPF consumption and a spectrum of adverse pregnancy outcomes. Higher intake of UPFs before or during pregnancy is associated with increased risks of gestational diabetes mellitus (GDM) and preeclampsia (PE) [7, 15]. At the same time, although most studies have not identified consistent and robust effects of UPFs on birthweight or other neonatal anthropometric indicators, the evidence base remains heterogeneous, underscoring the need for further testing using more rigorous study designs. In terms of exposure pathways, UPFs may also constitute an important source of persistent chemicals, such as per and polyfluoroalkyl substances (PFAS), which can be transferred via the maternal fetal route and pose potential threats to maternal and infant health[16]. Beyond food related risks, exposure to potentially teratogenic substances among pregnant women is far from rare: population level use of caffeine, alcohol, and certain medications during pregnancy remains prevalent [17, 18].

Crucially, deficits on the information and service supply side can further magnify these risks. Due to insufficient communication about nutrition and risk from healthcare providers, many pregnant women continue to consume UPFs and other risk related products in the absence of clear, actionable guidance [19, 20]. Socioeconomic and demographic factors also shape exposure patterns: lower educational attainment and higher parity have been linked to greater UPF intake, indicating the need for more targeted and accessible health education and interventions [21-23]. At a more macro level, the hypermodern consumption and communication environment, driven by platform based retail, algorithmic recommendation, and influencer marketing, intensifies the vulnerability of pregnant consumers [24, 25]. This context strengthens the institutional imperative for upstream information disclosure and risk signalling by states and suppliers, in order to enhance pregnant women's autonomy in decision making and their nutrition literacy [26, 27].

Taken together, governance of unhealthy foods among pregnant consumers should adopt evidence informed, integrated strategy. On the one hand, standardized public health policies and market instruments are needed to reduce the availability and persuasive power of high risk products; on the other hand, clinical and public nutrition education should be leveraged to enhance risk perception and health decision making capacity among key subgroups, thereby improving maternal and child health outcomes.

### *4C framework: consumer, content, commodity, and context*

Figure 1 illustrates the 4C framework, which conceptualizes four core dimensions and their hierarchical relationships in the study of unhealthy commodities. Consumer focuses on who consumes and why they consume, identifying sensitive populations such as pregnant women together with their motivations and vulnerabilities.

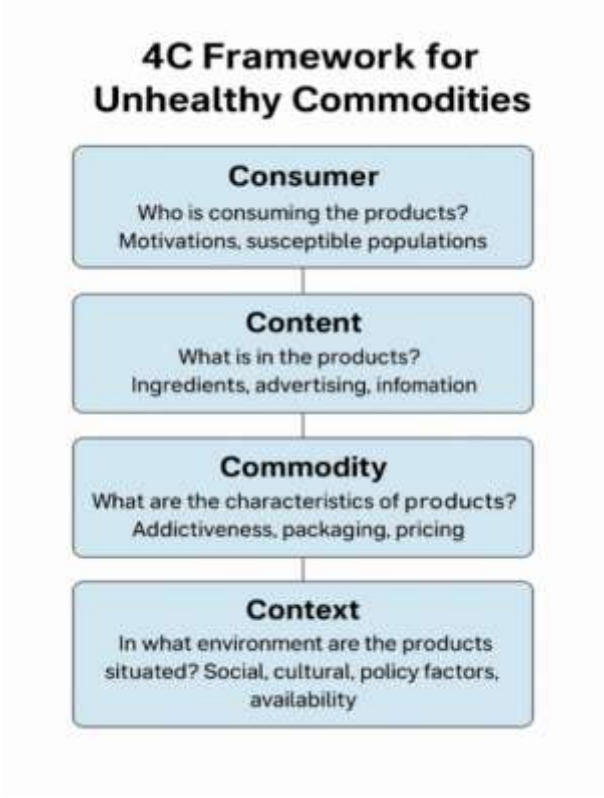


**Figure 1:** 4C frameworks for the unhealthy commodities

Content addresses what is contained within the product, encompassing both its composition and communicative elements. This includes ingredients such as sugar, caffeine, additives, and potential exposures, as well as packaging, advertising, and information presentation that shape consumers' perception of risk. Commodity defines the characteristics of the product, including addictiveness, pricing and promotion, packaging design, and portability, all of which influence palatability and affordability.

Context explains the environment in which the product exists, including sociocultural norms, policy and regulatory instruments such as minimum unit pricing, retail licensing and density control, online sales restrictions, pregnancy specific warnings, influencer disclosure rules, algorithmic downranking, and product accessibility [28]

Viewed through the 4C lens of Consumer, Content, Commodity, and Context, studies on unhealthy commodities during pregnancy reveal a growing but fragmented evidence base. At the Consumer level, pregnant women are a particularly vulnerable group because of their biological sensitivity and intergenerational implications. Sociodemographic attributes correspond to distinct consumption patterns; for instance, marital status and physical activity have been associated with higher UPF intake, suggesting that interventions should focus on identifiable subgroups [29]. At the Content level, persuasive digital marketing and influencer endorsements strongly shape attitudes and social norms, reinforcing preferences for unhealthy products among young and reproductive age women [30]. At the Commodity level, UPFs characterized by industrial additives and chemical modification are linked with increased risks of gestational diabetes mellitus (GDM) and preeclampsia (PE) [7, 31]. The consumption of sugar and artificial sweeteners may also contribute to excessive gestational weight gain and alter maternal and fetal metabolic programming [32]. Moreover, UPFs can serve as carriers for persistent chemicals such as PFAS, which may transfer from mother to fetus [16]. At the Context level, clinical and nutritional guidelines emphasize the dual objectives of ensuring adequate nutrition and avoiding environmental toxins [33], yet broader market and platform governance related to availability, affordability, and online reach remains uneven.

Based on this review, three key gaps highlight the importance of the present study. First, few studies have integrated all four Cs within a maternal health context. Most have focused narrowly on linear relationships between a single product and outcome, such as UPFs and GDM or PE, or on content exposure effects, while lacking models that explain how content and context interact with consumer heterogeneity to shape actual market behavior [7, 34, 35]. Second, the evidence on the transferability of policy tools remains limited. Measures originally developed for tobacco and alcohol regulation, such as pricing strategies, retail licensing, and advertising restrictions, have rarely been tested for their cross commodity and cross context applicability to UPFs and sugar sweetened products, nor have they been aligned with clinical objectives for minimizing toxic exposure[36, 37]. Third, exposure science and market analytics have not been sufficiently integrated. Fine grained measurements of UPF composition and PFAS exposure pathways are seldom linked with platform

level marketing telemetry or stratified risk analysis[16]. To address these gaps, this study proposes the Maternal 4C framework. First, it consolidates cross commodity examples such as UPFs, sugar sweetened beverages, nicotine, and alcohol, together with cross jurisdictional regulatory practices, to systematically assess the transferability and complementarity of policy instruments including minimum unit pricing, retail licensing and density control, pregnancy specific warnings, online sales restrictions, advertising and influencer disclosure requirements, and algorithmic downranking in reducing exposure and purchase intention among pregnant women. Second, it identifies the conditions and mechanisms under which these policies succeed or fail when transferred from one product category or jurisdiction to another.

Based on these findings, the study advances maternal health strategies consistent with the Sustainable Development Goals, emphasizing the integration of traditional retail regulation with digital platform governance involving advertising control and algorithmic moderation to promote cross jurisdictional policy learning and diffusion.

### *Frameworks for control of unhealthy commodities*

Enforcement and control of other harmful commodities have evolved independently, and frequently substantially differently in different jurisdictions, in contrast to the integrated policies and procedures surrounding "illicit drugs" as outlined in the international "narcotic drug" treaties. There has been an expansion in the types of control regimes in recent years, with several jurisdictions and countries removing cannabis from their drug treaty control system and more and more countries legalizing its nonmedical use [38, 39]

It is important to examine the licensing and control systems in different jurisdictions and for different commodities to see how they compare. This will help us figure out how to make these systems work together better, with control efforts being proportional to the harm caused by the controlled product.

In light of the public health community's recent shift toward a more systemic approach to examining "unhealthy commodity" industries, this article takes a look at potential next steps for putting this theory into practice. Here is the question we are trying to resolve: Is there a set of rules and regulations that has worked to rein in the sale of a particular unhealthy product in one country that could work in another? Dietary guidelines, media advertising campaigns, warning labels, marketing restrictions, taxes to increase relative costs, portion-size restrictions, and farm subsidies for healthier alternatives are some of the potential measures lists as possible actions that governments can take to regulate the food industry [40- 43]. When we take a broader view of harmful goods, we can classify their marketing restrictions as follows: prohibitions or limits on advertising; restrictions on sale-times by day of the week and under what circumstances; limitations on the quantity and type of retail sales outlets; and the requirement of a license to sell or serve the commodity. The methods of limitation enforcement should also be carefully considered; for example, a dedicated agency could be established to oversee licensing and the implementation of sales restrictions. Figure 2 shows the frameworks.

## Methods

To align with the research objective of assessing the cross commodity and cross jurisdictional transferability of policy instruments, this study employed a qualitative semi structured interview design, guided by the Maternal 4C framework (Consumer, Content, Commodity, and Context) as a sensitizing structure for both interview protocol development and analytical dimensions. The sample was obtained through purposive and maximum variation sampling to ensure diversity among pregnant women and recent mothers in terms of gestational stage, education level, platform dependency, and UPF or sugar sweetened beverage consumption. A total of 37 pregnant participants were interviewed, recruited primarily from hospital outpatient settings. Specifically, participants were approached in the obstetrics outpatient clinics of Chongqing Maternal and Child Health Hospital and Chongqing First People's Hospital, two large public tertiary hospitals in Chongqing, China. Data collection followed the principle of thematic saturation, whereby recruitment ceased once no

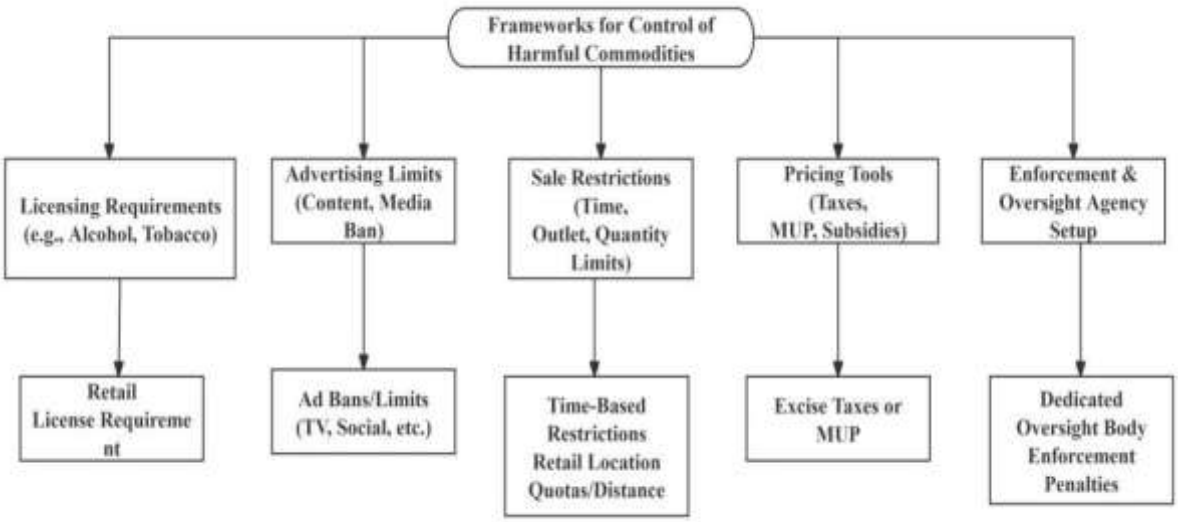


**Figure 2:** Frameworks for control of harmful commodities

new codes emerged after three consecutive interviews. Interviews were conducted either face to face or via encrypted video conferencing, each lasting 45 to 75 minutes, and were audio recorded and transcribed verbatim with informed consent.

Data were analyzed using the Framework Method, supplemented by abductive coding. Initially, two researchers independently conducted open coding to develop a codebook structured around the Maternal 4C framework and key policy instruments, including minimum unit pricing, retail licensing and density regulation, online sales restrictions, pregnancy specific warnings, advertising and influencer disclosure requirements, and algorithmic downranking. Emergent themes were incorporated throughout this process. Subsequently, a thematic matrix was constructed to cross tabulate data by respondent category, the four Cs (Consumer, Content, Commodity, Context), commodity type, jurisdiction, and policy mechanism. This matrix enabled cross case comparison to identify the contextual conditions under which policy transfer succeeded or failed, as well as patterns of policy complementarity. Negative cases were subjected to thick description to enhance explanatory validity.

Data management was conducted using NVivo and Atlas.ti. To ensure reliability, 25 percent of the sample was recoded independently to test for inter coder agreement (Cohen's $\kappa \geq 0.70$), with discrepancies resolved through discussion and consensus. Credibility was enhanced through member checking and peer debriefing; transferability was supported by detailed contextualization of setting and sample composition following COREQ guidelines; and dependability and confirmability were maintained through an audit trail and reflexive memos.

The study strictly adhered to ethical protocols for research involving pregnant and postpartum women, recognized as a sensitive population. All participants provided written informed consent after receiving full information about the study purpose, potential risks, and their right to withdraw at any stage.

## *Descriptive statistical analysis*

A total of 37 pregnant consumers participated in this study. Participants represented a diverse range of sociodemographic and behavioral characteristics in order to capture the heterogeneity of pregnant women's exposure to unhealthy commodities. The participants' ages ranged from 21 to 39 years (mean = 29.4 years), and gestational weeks ranged from 8 to 38 weeks at the time of the interview. Most participants were married and resided in urban areas with regular access to online retail platforms. Educational attainment and digital engagement varied considerably, allowing for stratified analysis

of consumer behaviors, nutritional awareness, and dependence on platform based purchasing and marketing exposure. The sample distribution and descriptive statistics are summarized in Table 1.

The results show that more than half of the respondents (51.4%) reported consuming ultra processed foods (UPFs) at least one to three times per week, while nearly one third (32.4%) consumed them four or more times per week. Likewise, 59.5% of participants reported continued caffeine intake during pregnancy, primarily through tea or coffee. Frequent users of online platforms (approximately 75.6%) demonstrated greater exposure to health related marketing content, both promotional and misleading, particularly those framed as "low sugar" or "pregnancy safe." Despite a moderate level of overall awareness regarding the risks of UPFs and sugar sweetened beverages, 32.5% of participants exhibited low risk awareness, indicating the persistence of informational and behavioral gaps.

These descriptive results provide an empirical foundation for the subsequent thematic and cross case analyses presented in later sections, where the interactions among consumer characteristics, product exposure, and contextual policy factors are further examined within the Maternal 4C framework.

## *Coding process and analytical focus*

The qualitative analysis began with independent open coding by two researchers. The codebook that emerged was organised around two linked elements. The first element was the Maternal 4C framework, which distinguishes consumer, content, commodity and context. The second element was the set of policy instruments that are central to this study, including minimum unit pricing, retail licensing and outlet density control, online sales restrictions, pregnancy specific warning messages, advertising and influencer disclosure rules and algorithmic downranking. This structure provided an analytic spine while still allowing new themes to emerge from the interview material.

In practical terms, all interview transcripts were read line by line and coded for any segment that spoke to at least one of the 4Cs, to one of the policy tools, or to the way these dimensions interact. Codes linked to the consumer dimension captured how pregnant women described their everyday choices, their perception of risk and benefit, and the social and economic pressures that shape their use of ultra processed foods, sugar sweetened beverages, nicotine and alcohol. Codes linked to content covered both product composition, such as sugar, caffeine, additives and possible PFAS exposure, and the persuasive elements of packaging, claims and digital advertising that influenced how safe or unsafe a product was perceived to be.Within the commodity dimension, the coding focused on features that make products easy to use and difficult to avoid, such as taste, price, portion size, portability and the availability of low cost multi buy promotions. This allowed us to trace how these features translated into concrete purchasing routines during pregnancy. Finally, the context dimension grouped codes about the wider regulatory and social environment, including awareness of existing rules, experiences with warning labels, perceptions of enforcement in physical retail, and the visibility or absence of controls on major e commerce platforms. Stakeholders from health, retail and platform sectors contributed additional codes that highlighted gaps between formal regulation and what actually happens in the market.

By structuring the open coding in this way, the analysis kept the focus on how individual experiences, market practices and regulatory arrangements fit together. The resulting codebook links specific narratives from pregnant consumers to particular policy tools and to the four Cs of the Maternal 4C framework. This provides the empirical basis for the cross case comparisons and policy transfer analysis presented in the following sections.

## *Ethical approval*

This study was approved by the Academic Ethics Committee of the Pass College of Chongqing Technology and Business University (Approval No. CQGSPS-20250423) and conducted strictly in accordance with the approved ethical protocol.

**Table 1:** Demographic and behavioral characteristics of the participants (n = 37)

| Variable | Category | Frequency (n) |
|---|---|---|
| **Age Group (years)** | 21–25 | 8 |
| | 26–30 | 14 |
| | 31–35 | 10 |
| | 36–39 | 5 |
| **Gestational Stage** | Early pregnancy (≤12 weeks) | 6 |
| | Mid-pregnancy (13–27 weeks) | 15 |
| | Late pregnancy (≥28 weeks) | 16 |
| **Education Level** | High school or below | 9 |
| | Bachelor's degree | 18 |
| | Master's degree or above | 10 |
| **Occupation** | Full-time employed | 12 |
| | Part-time employed | 8 |
| | Unemployed / Homemaker | 17 |
| **Household Income (Monthly, CNY)** | <5,000 | 7 |
| | 5,000–10,000 | 16 |
| | >10,000 | 14 |
| **Platform Use Frequency (Online Shopping)** | Daily | 11 |
| | Several times a week | 17 |
| | Occasionally | 9 |
| **UPF Consumption Frequency** | Rarely (<1 time/week) | 6 |
| | Occasionally (1–3 times/week) | 19 |
| | Frequently (≥4 times/week) | 12 |
| **Sugar-Sweetened Beverage Consumption** | None / Rarely | 10 |
| | 1–3 times/week | 15 |
| | ≥4 times/week | 12 |
| **Caffeine Intake During Pregnancy** | Yes | 22 |
| | No | 15 |
| **Awareness of UPF Risks** | High | 9 |
| | Moderate | 16 |
| | Low | 12 |

# Results

## *Cross-case comparative matrix and synthesis*

Following the initial coding, a thematic matrix was constructed to integrate perspectives across respondent groups, product categories, jurisdictions, and policy instruments, framed by the Maternal 4C structure.This matrix enabled systematic comparison along the intersections of individual experiences, market features, and regulatory mechanisms, revealing how policy transferability varies across commodities and governance settings. Table 2 systematizes cross-case insights using the Maternal-4C framework to compare how individual vulnerability, digital marketing logics, product attributes, and governance settings jointly shape maternal exposure to harmful commodities (e.g., UPFs and sugary beverages). Rows summarize, for each 4C dimension, key terms, mechanisms/risk pathways, policy levers, interview-observed effects, transfer/adaptation notes, and (vi) potential indicators. Two synthesis rows, transferability and complementarity, extend the matrix by theorizing when policies migrate effectively across commodities/jurisdictions and how instrument bundles (fiscal + informational + platform governance) produce amplified effects.Constructed from thematic cross-case coding of semi-structured interviews, the matrix supports analytic generalization rather than statistical inference, enabling structured comparison, identification of context-mechanism-outcome (CMO) patterns, and design of sequenced, platform-aware interventions.

**Table 2:** Maternal-4C cross-case comparative matrix and synthesis

| 4C Dimension | Key terms | Mechanism / Risk pathway | Policy levers (examples) | Observed effects from interviews | Transfer / adaptation notes | Potential indicators / metrics |
|---|---|---|---|---|---|---|
| Consumer | Digital literacy; access to healthcare information; income level; prenatal counseling; susceptibility to influencer content; heterogeneity | Lower literacy/income increases susceptibility to 'low-sugar' / 'pregnancy-safe' claims and influencer appeals; higher literacy counters misleading claims. | Targeted prenatal counseling; segmented risk communication; influencer disclosure rules; digital literacy programs for expectant mothers. | Higher-literacy participants recognized misleading claims; lower-income/limited-counseling participants were more persuaded by emotional/influencer marketing. | Policies must be tailored by socio-economic and literacy profiles; pair disclosures with community health outreach to close information gaps. | Digital literacy index; prenatal counseling coverage; ad recall and understanding; susceptibility scores by SES. |
| Content | Personalized advertising; algorithmic recommendation; health-washing narratives; formal warnings; information asymmetry | Platform personalization and persuasive narratives undermine static labels/taxes; warnings get drowned out by tailored content. | Algorithmic downranking of harmful content; mandatory pregnancy warnings in digital ads; standardized influencer disclosures; ad targeting restrictions. | Persuasive, tailored content often overrode health warnings; labeling/taxation alone had limited salience in digital journeys. | Transferring tools from alcohol/tobacco requires platform-aware informational controls and enforcement APIs. | Share of exposures via personalized feeds; warning viewability rate; disclosure compliance; ad targeting audits. |
| Commodity | Pricing; packaging; MUP (minimum unit pricing); retail licensing; UPFs; sugary beverages; online convenience; substitution | Price/pack cues nudge habitual purchases; MUP and licensing reduce impulse/volume; online channels re-enable affordability and convenience. | MUP and sugar taxes; pack size limits; retail density/licensing ; online sales constraints (age/type gating, time/place restrictions). | Where MUP/licensing existed, lower purchase frequency and healthier substitution; in unregulated/online markets, UPF/sugary drink consumption persisted. | Economic tools transfer well if paired with online enforcement and pack architecture rules to prevent circumvention. | Effective price per unit sugar; pack size distribution; retail density; online basket share of UPFs. |

| | | | | | | |
|---|---|---|---|---|---|---|
| Context | Inter-agency coordination; enforcement capacity; platform collaboration; fragmented governance; cross-sector communication | Coordinated oversight aligns objectives and enforcement across health, retail, and platforms; fragmentation weakens deterrence. | Joint taskforces (health-retail-platform); shared data protocols; harmonized penalties; cross-border cooperation for platforms. | Coordinated regions showed better alignment between policy goals and outcomes; fragmented settings diluted policy effects. | Contextual fit is critical—formal tools require governance capacity and platform MOUs to replicate outcomes. | Number of joint operations; enforcement SLA with platforms; penalty collection rate; cross-agency data sharing events. |
| Synthesis: Transferability | Cross-commodity policy transfer; platformized retail; contextual compatibility | Alcohol/tobacco tools only reproduce effects for UPFs/sugary drinks when adapted to digital platform dynamics and local governance. | Translate MUP/pack rules to e-commerce; require platform-level warning delivery; portability clauses for digital enforcement. | Transfer success varied by platform rules and local enforcement; without adaptation, impact attenuated. | Assess platform governance, legal remit, and data access before transfer; pilot with rapid feedback loops. | Policy replication score; enforcement coverage online vs offline; time-to-compliance on platforms. |
| Synthesis: Complementarity | Sequencing; fiscal + informational + digital governance | Combined instruments amplify impact (e.g., MUP + pregnancy warnings + algorithmic downranking) vs. single-tool deployment. | Staged rollout: (1) fiscal floors, (2) mandatory disclosures/warnings, (3) platform ranking controls and influencer rules. | Participants reported strongest shifts where multiple tools co-occurred (price + warnings + reduced ad visibility). | Design bundles with explicit sequencing and cross-agency ownership; monitor for substitution channels. | Bundle adoption index; exposure reduction in feeds; substitution to healthier categories; maternal risk score change. |

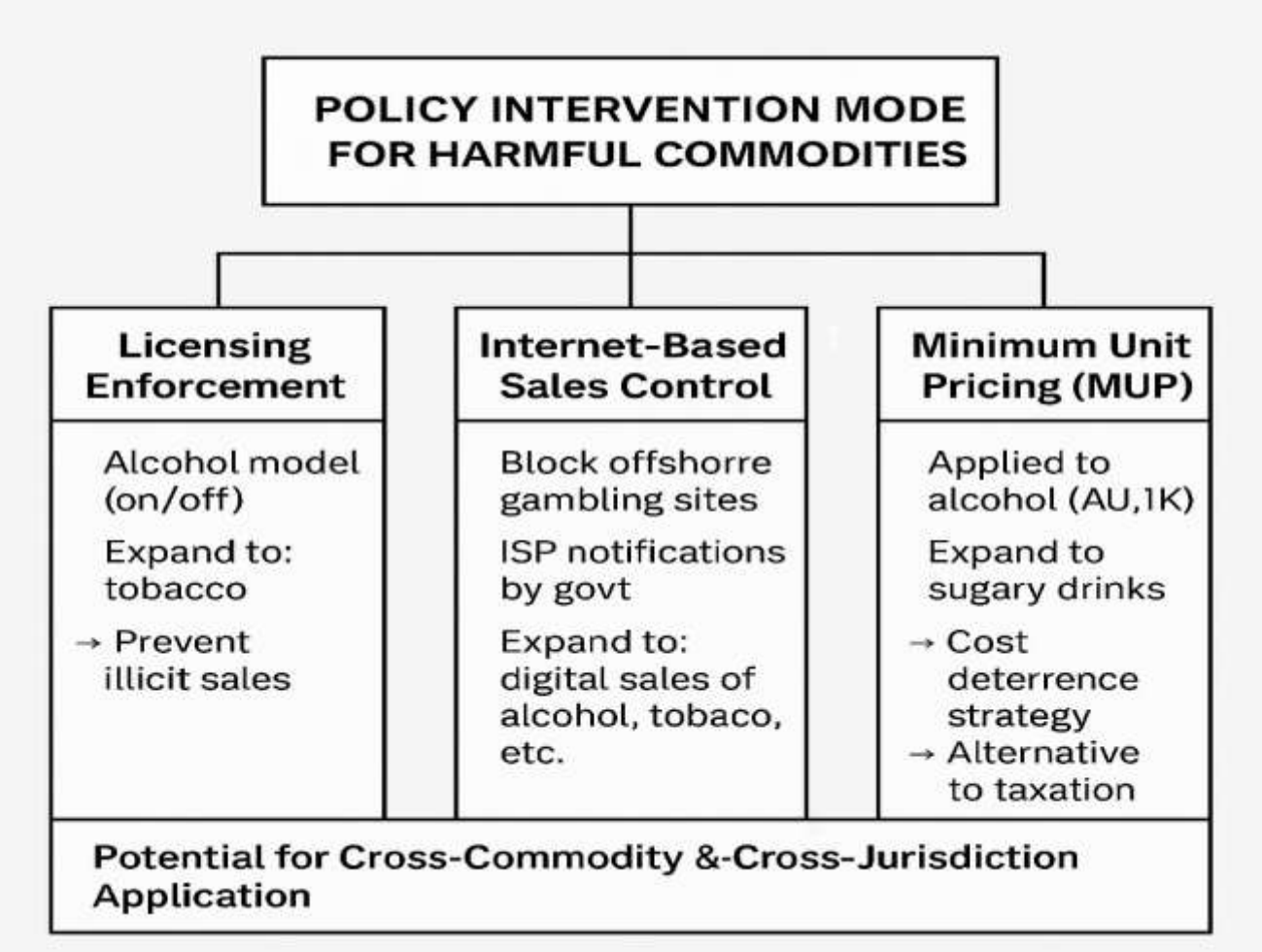


**Figure 3:** Policy intervention model for harmful commodities

The cross case comparison demonstrated several consistent and divergent patterns. Pregnant consumers in different social and economic strata exhibited varying degrees of susceptibility to unhealthy commodities. For instance, respondents with stronger digital literacy and stable access to healthcare information tended to recognize misleading "low sugar" or "pregnancy safe" claims, while those with lower income or limited prenatal counseling were more easily persuaded by emotional or influencer based marketing. This finding underscores how consumer heterogeneity shapes the real world outcomes of regulatory measures.

At the content level, the matrix showed that digital marketing strategies, particularly personalized advertising, algorithmic recommendation, and health washing narratives, had more significant influence than traditional product labeling or taxation alone. Interviewees described how persuasive content often undermined formal health warnings, indicating that information asymmetry remains a critical barrier to effective policy implementation.

The commodity dimension highlighted that pricing and packaging factors directly mediate behavioral outcomes. In markets where minimum unit pricing (MUP) or retail licensing restrictions were enforced, participants reported lower purchase frequency and greater product substitution towards healthier options. However, in unregulated or online settings, the affordability and convenience of ultra processed foods (UPFs) and sugary beverages sustained habitual consumption despite awareness of risks. The context dimension revealed jurisdictional differences in policy enforcement.

Regions with coordinated inter agency oversight, linking health authorities, retail regulators, and digital platforms, showed better alignment between policy objectives and consumer outcomes. In contrast, fragmented governance and limited cross sector communication weakened the deterrent effect of otherwise robust policy tools.Synthesizing across these dimensions, two key insights emerged. First, policy transfer success depends on contextual compatibility: interventions originating from alcohol or tobacco regulation can only achieve similar effects for UPFs or sugary drinks when adapted to the platformized retail environment. Second, policy complementarity amplifies impact: fiscal instruments (e.g., MUP), informational controls (e.g., pregnancy warnings), and digital governance (e.g., influencer disclosure and algorithmic downranking) work best when deployed in coordinated sequences rather than isolation. These insights formed the empirical foundation for the two integrative models presented in the subsequent sections.

### *Policy intervention model for unhealthy commodities in the context of maternal health*

Building upon the cross case synthesis, Figure 3 presents a policy intervention model that illustrates how different regulatory instruments can be adapted across harmful commodities to address maternal health risks. The model integrates three core mechanisms, licensing enforcement, internet based sales control, and minimum unit pricing (MUP), each representing a distinct yet complementary policy pathway with potential for cross commodity and cross jurisdictional application.

Licensing enforcement originates from the alcohol control model and demonstrates how regulatory authorization can serve as an effective on off switch for access to harmful commodities. By restricting retail density, imposing sales hours, and linking license conditions to compliance with health communication standards, such systems can prevent the unregulated distribution of products like alcohol, tobacco, or energy drinks. The analysis suggests that extending this model to UPFs and sugary beverages would enable local authorities to monitor sales environments that target pregnant consumers, thereby reducing impulsive or high risk purchasing behaviors.

Internet based sales control represents the most recent regulatory frontier, addressing the migration of harmful commodities into digital markets. As demonstrated by online gambling and cross border tobacco sales controls, measures such as blocking offshore retail sites, ISP notifications, and digital advertising restrictions can significantly curb illegal or deceptive online transactions. Extending these mechanisms to digital platforms where pregnant women frequently engage, such as e commerce, food delivery, or social media marketplaces, would help mitigate exposure to persuasive marketing and misleading “pregnancy safe” claims. This reflects the growing need for platform level maternal protection mechanisms, linking public health regulation with algorithmic governance.

Minimum Unit Pricing (MUP) offers a cost based deterrence strategy, first implemented in alcohol control policies in countries such as Australia and the United Kingdom. By setting a price floor per unit of harmful content (e.g., sugar or alcohol), MUP discourages overconsumption and reduces affordability of high risk products without relying on traditional taxation. The model’s transferability to sugary drinks and UPFs lies in its ability to integrate fiscal and behavioral dimensions, raising the economic barrier for habitual consumption while maintaining market neutrality.

Overall, the model underscores that no single intervention is sufficient to protect maternal and child health in the face of platformized and globalized commodity systems. Instead, the combination of licensing enforcement, digital sales regulation, and pricing policies forms a multi layered governance architecture capable of addressing both physical and virtual retail channels. This integrative approach supports the development of maternal health strategies aligned with the Sustainable Development Goals (SDG 3 and SDG 12), enabling cross sector collaboration between health authorities, commerce regulators, and digital platforms.

### *4C new marketing strategies towards maternity health*

Building on the Maternal 4C framework, Figure 4 conceptualizes how contemporary marketing ecosystems employ consumer centred, content driven, commodity enhanced, and context embedded strategies to influence pregnant women's purchasing behaviour. Rather than functioning independently, these dimensions operate interactively within platformized markets, collectively shaping risk perception, emotional attachment, and habitual consumption patterns during pregnancy.

At the consumer level, digital marketing technologies enable data driven segmentation that identifies and targets women in reproductive age groups through search histories, pregnancy tracking apps, and online shopping data. Personalized advertisements use behavioural nudging and emotional resonance to promote convenience oriented or "healthy looking" products such as low sugar beverages and fortified snacks. Loyalty schemes and subscription models further encourage habit formation, reducing consumers' perceived agency and reinforcing daily exposure to ultra processed foods (UPFs).

The content dimension refers to the persuasive messages embedded in product communication. Marketers increasingly use health washing tactics, combining emotional storytelling and influencer endorsements to portray UPFs or sugary drinks as safe, energy boosting, or even beneficial for pregnancy. Attractive packaging and vague nutritional claims such as "organic," "low fat," or "for expectant mothers" contribute to information asymmetry, blurring the line between medically recommended nutrition and commercially engineered products. Such framing manipulates the risk perception of pregnant women, especially those with limited access to professional dietary guidance.At the commodity level, firms exploit formulation and design innovations to maximise product appeal. Convenient packaging, single serve portions, and diversified flavour variants are deliberately developed to suit pregnant women's daily routines. Addictive taste formulations and low pricing strategies further enhance accessibility, particularly in lower income segments. The interplay between affordability, palatability, and perceived safety transforms UPFs into everyday staples rather than occasional indulgences, amplifying cumulative health risks for both mother and fetus.

Finally, the context dimension reflects how these marketing strategies interact with broader social and regulatory environments. Companies leverage policy loopholes and cross jurisdictional marketing to bypass national advertising restrictions by disseminating content through digital platforms, transnational e commerce, and social media influencers. The marketing message is then localised through cultural adaptation, using imagery of family care, maternal responsibility, and wellbeing to normalise consumption. Meanwhile, retail environment manipulation, such as product placement in baby care aisles or pregnancy related mobile apps, further reinforces behavioural triggers. Collectively, these findings reveal a multi layered commercial ecosystem that actively constructs and sustains unhealthy consumption patterns among pregnant women. Understanding this dynamic through the Maternal 4C lens highlights the necessity for integrated counter strategies: transparent information governance, platform accountability, and health communication interventions that neutralise the persuasive power of commercial narratives.

### *Integrative conceptual framework for maternal health governance*

Building on the Maternal 4C framework, this study constructs an integrative model to illustrate how multi-level policy interventions can mitigate pregnant women's exposure to unhealthy commodities. As shown in Figure 5, the framework synthesizes the micro level behavioral mechanisms of pregnant consumers, the meso level marketing and algorithmic systems of digital platforms, and the macro level governance instruments that jointly shape maternal and fetal health outcomes. This model not only visualizes the dynamic interaction between consumer cognition, market persuasion, and regulatory control but also explains the transferability and complementarity of policy tools across commodities and jurisdictions, thereby addressing Research Objective 1.

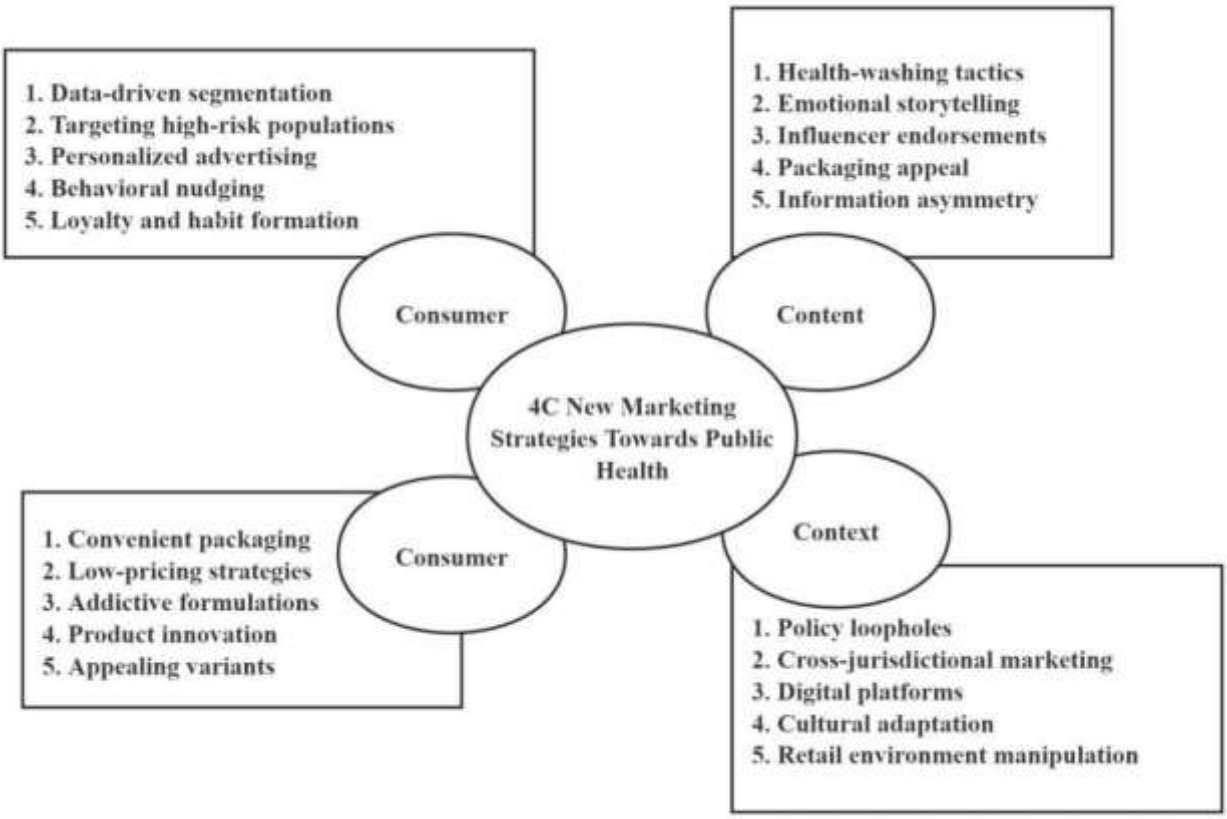


**Figure 4:** 4C new marketing strategies towards maternity health

At the micro level, pregnant consumers' behavioral responses are driven by perceived necessity, perceived safety, and risk perception, each influenced by health beliefs, social norms, and perceived behavioral control. These factors explain why pregnant women may continue consuming ultra-processed foods, sugary drinks, or other risky commodities despite awareness campaigns. The micro level reflects the psychological and contextual vulnerability emphasized in maternal health studies, where information asymmetry and platform mediated normalization of risk play decisive roles.

At the meso level, the model incorporates digital marketing systems and influencer driven promotion as central mediators translating policy environments into consumer behavior. Algorithmic recommendation mechanisms amplify exposure to persuasive content, while influencer endorsements and personalized advertising reinforce consumption intentions through emotional and normative appeals. The Maternal 4C lens operates across this layer, enabling a systematic classification of drivers that shape both individual and collective maternal risk environments. The framework highlights that algorithmic downranking, transparency mandates, and disclosure rules are essential to break the marketing behavior feedback loop that perpetuates unhealthy consumption among pregnant women.

At the macro level, fiscal, commodity, and content based policy tools jointly constitute the governance structure. Fiscal measures such as minimum unit pricing and taxation aim to modify price incentives; commodity related interventions like retail licensing and supply side restrictions regulate product availability; and content related instruments, including pregnancy specific warnings and influencer disclosure, target information visibility and persuasive marketing. Complementary context based interventions, such

as algorithmic down ranking and online sales restrictions, extend regulatory oversight into the digital sphere. Together, these measures represent a multi entry governance architecture capable of altering price, availability, information exposure, and algorithmic visibility, which are identified as key intervention points in this framework.

The lower section of the model conceptualizes transferability conditions, recognizing that the success or failure of policy migration depends on contextual factors such as enforcement capacity, platform governance maturity, cultural risk perception, and market structure. These conditions determine whether policy instruments originally designed for alcohol or tobacco regulation can be effectively adapted to ultra-processed foods, sugary beverages, or gambling products within varying digital or jurisdictional environments. The framework concludes with a feedback loop from maternal and fetal outcomes, such as gestational diabetes mellitus (GDM), pre eclampsia (PE), excessive gestational weight gain (GWG), and stress, to the macro policy domain, illustrating evidence based policy learning and iterative refinement.

Overall, the Integrative Framework for Maternal Health Governance visualizes how the Maternal 4C analytical lens bridges micro behavioral processes, meso marketing mechanisms, and macro regulatory interventions. It provides a transferable and adaptive structure for understanding and improving policy coordination across health related commodities and governance contexts.

## *Strategies for cross jurisdictional and cross commodity maternal health governance*

Building upon the diagnostic insights from the Maternal 4C framework, this section develops a comprehensive policy implementation model designed to formulate integrative, transferable policy strategies that can effectively mitigate commercial determinants of maternal health across both traditional retail and digital marketing ecosystems. Figure 6 illustrates the multilevel governance framework that integrates fiscal, regulatory, informational, and algorithmic interventions under a coordinated policy system.

At the macro policy level, the framework identifies four core regulatory domains, fiscal regulation, supply regulation, information regulation, and algorithmic governance, that collectively reshape the structural environment of maternal consumption. Fiscal regulation includes measures such as minimum unit pricing (MUP) and health oriented excise taxes that directly influence affordability and demand for unhealthy commodities. Supply regulation targets retail licensing, outlet density, and online sales restrictions to control the physical and digital availability of high risk products. Information regulation encompasses pregnancy specific warnings, front of package labeling, and mandatory influencer disclosure to counter misleading marketing. Algorithmic governance extends this control to digital environments, ensuring responsible recommendation systems, advertising transparency, and de prioritization of health harming content in online platforms.

The meso policy layer serves as the operational interface linking regulatory systems and market actors through policy platform stakeholder coordination mechanisms. This layer facilitates collaboration among public health agencies, e commerce platforms, retailers, and clinical service providers through shared governance, joint enforcement, and real time data exchange. Such coordination ensures that digital marketing regulations, platform compliance, and retail policies are coherently aligned, reducing policy fragmentation across sectors and jurisdictions.

At the micro policy level, interventions are localized through maternal consumers and community health systems. Targeted initiatives, including prenatal nutrition counseling, health education, and risk communication, empower expectant mothers to make informed consumption choices while strengthening the preventive role of community health institutions. These actions collectively foster behavioral change, improve health literacy, and build resilience against commercial marketing influence.

Across all levels, the framework emphasizes enabling conditions, political will, institutional capacity, digital infrastructure, and public trust, that determine policy effectiveness and cross context transferability.

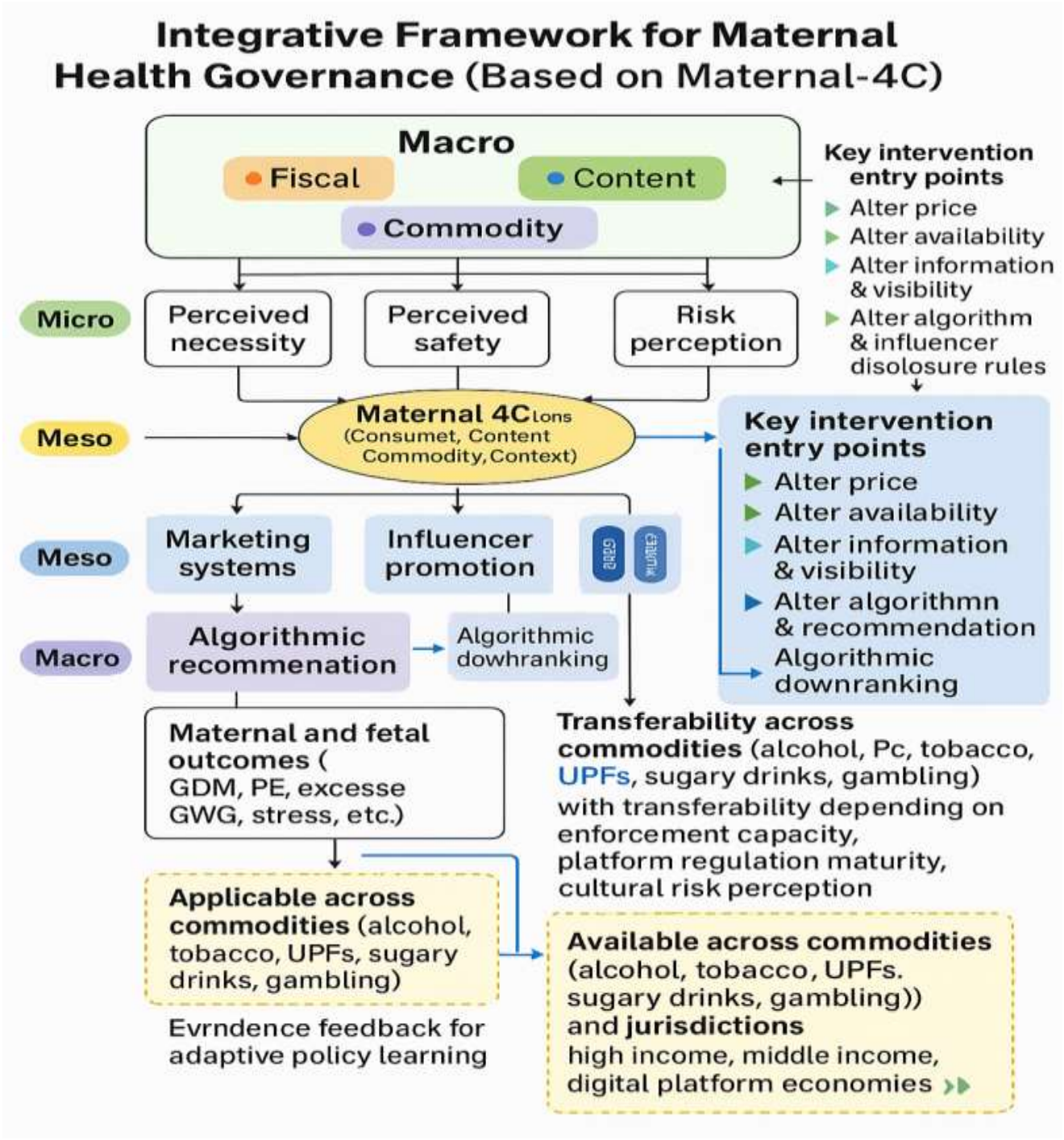


**Figure 5:** Integrative framework for maternal health governance (Based on Maternal 4C)

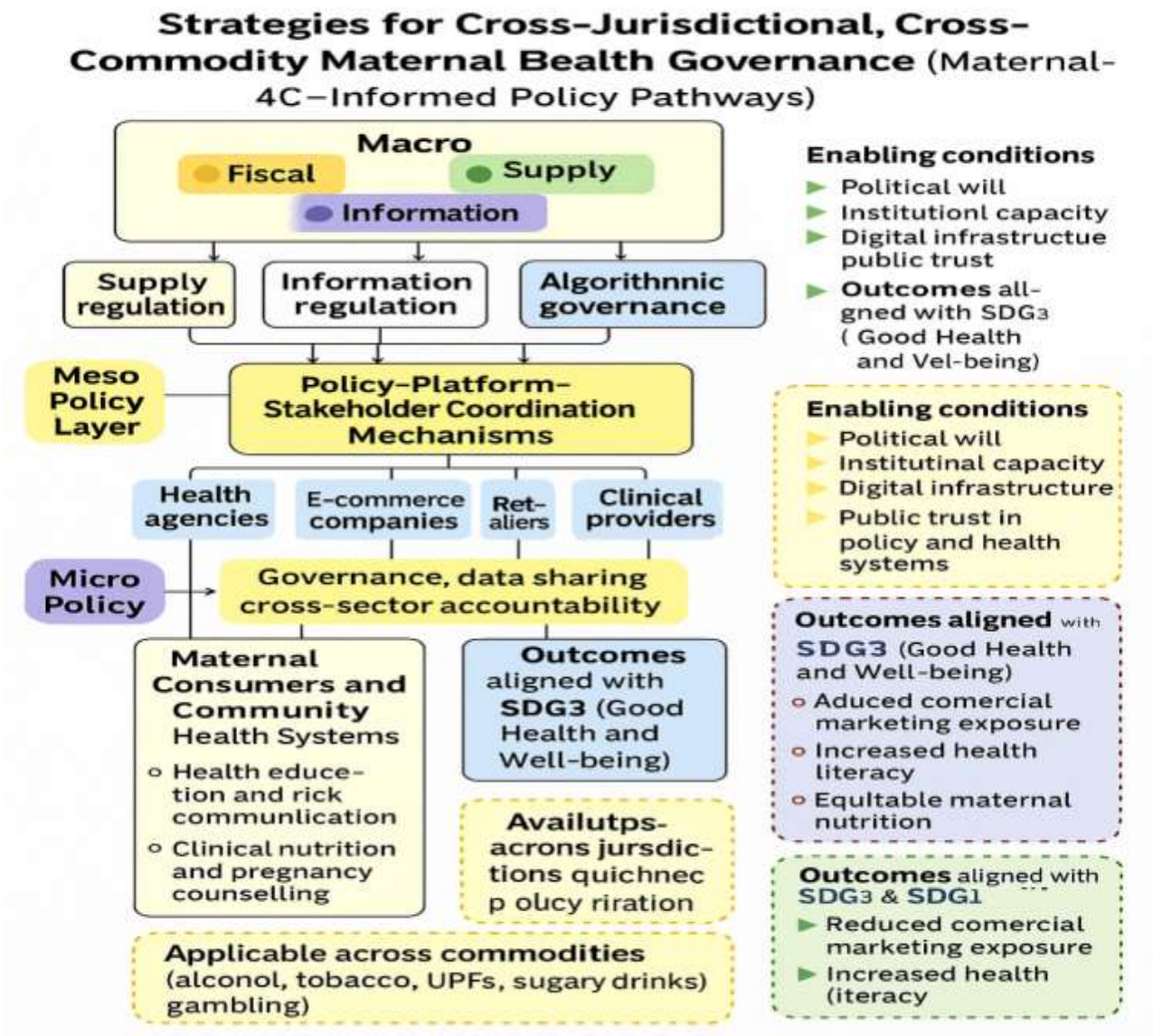


**Figure 6:** Strategies for cross jurisdictional and cross commodity maternal health governance (maternal 4c informed policy pathways)

The integrated governance structure aims to produce measurable outcomes aligned with the United Nations Sustainable Development Goals (SDG 3: Good Health and Wellbeing; SDG 12: Responsible Consumption and Production), including reduced commercial marketing exposure, increased maternal health literacy, and enhanced equity in nutritional outcomes. The model is designed to be applicable across multiple commodities, such as alcohol, tobacco, gambling, ultra processed foods (UPFs), and sugary drinks, and transferable across jurisdictions with different regulatory capacities and digital platform governance maturity.

## Discussion

### *Theoretical Implications*

Recent scholarship on public health and maternal wellbeing has made important progress in understanding the structural drivers of unhealthy

consumption. However, two major research streams have remained largely disconnected. Studies on the commercial determinants of health (CDoH) have revealed how industries producing alcohol, tobacco, ultra processed foods, and gambling services influence consumer environments through pricing, lobbying, and persuasive marketing [44- 46]. In contrast, research on maternal health has continued to focus primarily on nutrition, clinical care, and behavioral education, treating pregnant women's choices as individual decisions rather than outcomes of systemic market and informational pressures [47- 49]. While both lines of inquiry have generated valuable evidence, few studies have examined how pregnancy specific vulnerability interacts with the digitalized marketing ecosystems that now mediate access to food, beverages, and consumer goods.

Our interviews show that this interaction is not merely hypothetical. Pregnant women described daily exposure to "pregnancy-safe", "low-sugar", or "energy-boosting" products through livestreams, short-video feeds, and e-commerce promotions, often in direct tension with clinical advice received during antenatal visits. These narratives were particularly pronounced among participants with lower income and limited access to prenatal counselling, underscoring how pregnancy-specific vulnerability is actively amplified by platform-mediated marketing rather than simply existing in the background.

This study bridges these two perspectives by introducing the Maternal 4C framework, which

connects four analytical domains, into a single interpretive structure. Rather than isolating individual behaviors or single policy instruments, the framework views maternal consumption as the product of interdependent processes linking perception, persuasion, and governance. It reveals how pregnant women's perceptions of necessity, safety, and risk are shaped simultaneously by health narratives, product composition, and the regulatory and platform environments that define what is visible, affordable, and permissible. For instance, higher-literacy participants explicitly questioned "pregnancy-safe" claims and cross-checked them against professional guidance, whereas women with lower digital literacy or sporadic antenatal contact were more likely to accept influencer endorsements and health-washing narratives at face value.This integrative lens moves beyond conventional behavioral models, portraying maternal risk as a systemically produced condition rather than a personal choice deficit.

Traditional behavioral theories, such as the Health Belief Model and the Theory of Planned Behavior [50 , 51], have long provided useful explanations for health related decision making. Yet these models were developed in contexts where exposure, information, and access were assumed to be neutral or uniform. In digitalized markets, however, such assumptions no longer hold. Algorithms curate the content pregnant consumers encounter, platforms amplify influencer endorsements, and product visibility is engineered through data driven advertising. Within this environment, individual attitudes and intentions are continuously shaped by structural and algorithmic forces. The Maternal 4C framework extends these earlier theories by embedding psychological constructs within a wider socio technical and policy infrastructure. It shows how interventions that alter price, availability, or information visibility can reconfigure micro level perceptions and behaviors, producing a more comprehensive understanding of how structure and agency interact in maternal health outcomes.Within this environment, individual attitudes and intentions are continuously shaped by structural and algorithmic forces. Interventions that focus solely on changing beliefs or intentions, without modifying platform exposure, therefore risk over-estimating the impact of health education and under-estimating the need for structural and digital governance.

The framework also deepens theoretical understanding of policy adaptability and systemic governance. Previous work on public health regulation has typically treated fiscal, supply side, and informational measures as distinct tools, with limited analysis of how they interact or migrate across policy areas. By mapping these interventions onto the four analytical dimensions of the Maternal 4C framework, this study demonstrates that effective governance depends not only on what instruments are used but also on how they are combined and contextualized.The cross-case matrix indicates that instruments such as minimum unit pricing or retail licensing do not travel as

neutral, plug-and-play solutions: they only reproduce their protective effects for ultra-processed foods and sugary drinks when they are re-embedded in platform governance architectures and backed by credible enforcement. It identifies enforcement capacity, digital governance maturity, and cultural perceptions of risk as the underlying conditions that determine whether successful policies from tobacco or alcohol control can be adapted to domains such as ultra processed foods or digital marketing. In doing so, the research links the literature on commercial determinants of health with emerging theories of policy transfer and adaptive regulation, offering a more dynamic account of how policy learning can occur in the digital public health sphere.

Finally, this study situates maternal health governance within the broader agenda of sustainable development. By aligning the Maternal 4C approach with Sustainable Development Goals, especially SDG 3 on good health and wellbeing and SDG 12 on responsible consumption, the study reconceptualizes maternal health as a systemic outcome shaped by the balance between commercial freedom, technological infrastructure, and public accountability. It shifts theoretical attention from individual education and clinical intervention toward the structural interactions between markets, digital platforms, and regulatory institutions. This repositioning enables a more holistic vision of maternal wellbeing as both a health and governance issue, embedded in broader questions of economic power and sustainability.

In essence, the theoretical contribution of this research lies not in introducing a new construct, but in reassembling existing concepts into a coherent and scalable system. The Maternal 4C framework brings together individual psychology, market structures, and governance mechanisms to explain how maternal exposure to unhealthy commodities is produced and how it can be mitigated. It provides a theoretical foundation that integrates behavioral science, digital governance, and public health regulation into a unified model that is capable of explaining and guiding maternal health policymaking in an increasingly digital and commercialized world.

## *Practical implications*

The findings of this study hold significant practical implications for policymakers, public health authorities, digital platforms, and healthcare practitioners engaged in maternal health promotion. While prior interventions addressing unhealthy commodities have tended to focus on single categories such as tobacco, alcohol, or food taxation, they often lacked coordination across commodities, sectors, and governance levels. Moreover, most national health programs continue to treat maternal wellbeing as an individual behavioral issue, emphasizing health education and medical services rather than structural determinants.As interviews illustrate, this narrow focus leaves pregnant women structurally over-exposed to engineered demand for ultra-processed foods and sugary drinks in digital environments, even when they are aware of general nutritional advice. The Maternal 4C framework and its corresponding governance models developed in this study offer a pathway to overcome these limitations by translating theoretical insights into actionable strategies that operate across multiple levels of regulation and engagement.

At the macro policy level, the study provides a systematic foundation for designing comprehensive maternal health regulations that integrate fiscal, supply side, informational, and algorithmic interventions. Governments can adopt measures such as minimum unit pricing, taxation of ultra processed and sugary products, and retail density control to reshape the physical and digital availability of high risk commodities. Simultaneously, mandatory pregnancy specific warnings, transparent influencer disclosures, and algorithmic downranking of misleading content can reduce persuasive exposure in digital spaces. These instruments, when implemented as a coordinated portfolio, allow governments to manage both economic and informational environments rather than relying solely on post consumption education. The framework also underscores the importance of evidence informed policy evaluation: health outcomes such as reduced gestational diabetes or improved nutrition can serve as feedback mechanisms for policy refinement and resource

allocation.At the meso coordination level, the model encourages the establishment of collaborative governance mechanisms that connect public health institutions, e commerce platforms, and private retailers. Digital platforms should not merely act as distribution channels but as co responsible actors in health protection. Integrating public health compliance modules into advertising algorithms, flagging health sensitive content, and sharing anonymized exposure data with regulators can transform platforms into proactive partners in maternal wellness governance. Health ministries and regulatory agencies, in turn, can work with technology companies to create cross sector observatories that monitor exposure, marketing intensity, and content labeling. Such coordination fosters mutual accountability, transparency, and data driven decision making, which are essential for adaptive governance in fast evolving digital markets.Without re-defining platforms as accountable health actors, even stringent offline controls on pricing or outlet density are likely to be offset by persistent, high-intensity exposure to unhealthy commodities in online channels.

At the micro implementation level, the Maternal 4C framework provides practical guidance for healthcare providers, community organizations, and maternal education programs. Prenatal clinics and community health workers can integrate risk communication about unhealthy commodities into routine counseling sessions, using evidence based materials derived from policy frameworks. Community based nutrition education programs can be restructured to include modules on interpreting digital marketing claims, evaluating pregnancy safe labeling, and understanding the long term health implications of ultra processed foods. By enhancing media literacy and consumer empowerment, these measures bridge the gap between structural regulation and individual decision making. They ensure that women are not only protected by policy but also equipped with the skills to navigate commercialized digital ecosystems critically and independently.

Beyond its implications for specific stakeholders, this study also provides a practical template for cross jurisdictional policy learning. Countries and regions can adapt the governance models proposed here by tailoring fiscal tools, retail regulations, and digital oversight mechanisms to local contexts and capacities. The inclusion of transferability conditions such as enforcement capacity, political commitment, and platform governance maturity ensures that policy designs can be scaled or adjusted without losing effectiveness. This adaptability is particularly relevant for emerging economies where digital platforms are rapidly expanding but regulatory frameworks remain fragmented. The proposed integrated approach enables governments to coordinate maternal health, digital governance, and consumer protection policies under a unified public health strategy.

Beyond its policy and governance contributions, this study also offers a rich basis for curriculum reform and teaching innovation in higher education marketing programs. The Maternal 4C framework and the cross-jurisdictional strategy model can be used as a structured case to help students analyse how fiscal measures, supply-side regulation, pregnancy-specific warnings, marketing controls, and digital platform interventions reshape firms' incentives and responsibilities when targeting vulnerable consumers such as pregnant women. In courses on consumer behaviour, marketing communications, digital marketing, or marketing ethics, instructors can design case-based discussions, role-play exercises, and project-based assignments in which students critically evaluate real or simulated campaigns for unhealthy commodities, diagnose risks through the 4C lens, and redesign strategies aligned with public health protection and Sustainable Development Goals. Such activities not only strengthen students' analytical skills regarding commercial determinants of health, but also cultivate ethical sensitivity, reflexive judgment, and a long-term orientation toward responsible marketing practice. Furthermore, the framework can support interdisciplinary teaching collaborations with public health and policy faculties, enabling marketing students to better understand how their future professional decisions interact with regulatory regimes and platform governance. Through these pedagogical strategies, the present study contributes to ongoing higher education reforms that seek to move marketing education beyond narrow profit-maximization

logics toward a more socially responsible and sustainability-oriented curriculum.

## Conclusion

This study set out to examine how unhealthy commodities are marketed and consumed during pregnancy and to develop governance strategies, grounded in the Maternal 4C framework, that can be transferred across products and jurisdictions. Using qualitative interviews with 37 pregnant women and key stakeholders, analysed through the Maternal 4C lens and a cross-case comparative matrix, we showed that pregnant women's perceptions of safety and necessity are not purely individual, but are systematically shaped by digital marketing, product attributes and uneven regulatory environments. The analysis met the study objectives in several ways. First, it identified how the four domains of the Maternal 4C framework structure pregnant women's exposure to alcohol, tobacco, sugar-sweetened beverages and ultra-processed foods across consumer characteristics, media and platform content, product attributes and contextual environments. Second, it specified the mechanisms and enabling or constraining conditions under which policy tools such as minimum unit pricing, retail licensing and pregnancy-specific warnings can be transferred, combined and sequenced across different commodities and jurisdictions to protect maternal and child health. Third, it synthesised these insights into an integrative maternal health governance framework and a cross-jurisdictional strategy model that link fiscal, supply-side, informational and algorithmic interventions in a coherent way. Taken together, these contributions not only refine theoretical understanding of commercial determinants of maternal health and support coordinated policy and platform action aligned with the Sustainable Development Goals, but also provide a structured case and analytical scaffold for curriculum reform and responsible marketing education in higher education settings.. While further comparative and quantitative research is needed to test and extend these propositions, the present findings provide a practical and adaptable foundation for designing coordinated, digitally aware maternal health policies aligned with the Sustainable Development Goals

## Author contributions

Z. J: conceptualization, investigation, S.J: writing – original draft, Z.J & S.J: writing – review and editing, Z.J & S.J: data curation, Z.J & S.J: methodology.

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## Conflicts of interest

The authors declare no conflicts of interest

## Data availability statement

The data that support the findings of this study are available through public library..

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