

Negotiating food, family, and digital influences: Adolescent perspectives on type 2 diabetes prevention in Eastern Indonesia

Menyeimbangkan pengaruh makanan, keluarga, dan dunia digital: Perspektif remaja mengenai pencegahan diabetes tipe 2 di Indonesia Timur

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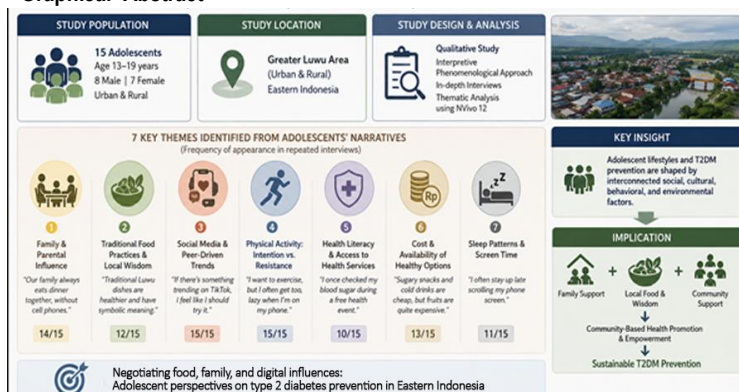
Abstract

Adolescent type 2 diabetes mellitus (T2DM) prevention has predominantly emphasized individual health education, while the family, social, cultural, and environmental contexts shaping everyday preventive behaviours remain insufficiently examined, particularly in Eastern Indonesia; this study addresses this gap by exploring adolescents' lived experiences across urban and rural settings. This qualitative study used an interpretive phenomenological orientation within a constructivist paradigm and was conducted in Luwu Raya, South Sulawesi, from March to August 2025. Adolescents aged 13–19 years without diagnosed T2DM or identified clinical risk were recruited using purposive maximum-variation sampling across residence and socioeconomic strata. Semi-structured in-depth interviews were conducted in participants' preferred languages or dialects and analysed using reflexive thematic analysis, with sample adequacy guided by information power. Seven themes emerged: family meals and parental influence; traditional food practices and local wisdom; social media and peer-driven diet trends; physical activity and resistance; health literacy and healthcare access; affordability and availability of healthy options; and sleep and screen time. Family food practices were protective, whereas peer, digital, and environmental influences often constrained healthy choices. Effective T2DM prevention should therefore combine family-based strategies, supportive environments, and culturally responsive approaches aligned with Islamic principles of moderation, health stewardship, and collective family responsibility.

Abstrak

Pencegahan diabetes melitus tipe 2 (DMT2) pada remaja selama ini lebih banyak menekankan pendidikan kesehatan pada tingkat individu, sementara konteks keluarga, sosial, budaya, dan lingkungan yang membentuk perilaku pencegahan sehari-hari masih belum banyak dikaji, khususnya di Indonesia Timur; penelitian ini mengisi kesenjangan tersebut dengan mengeksplorasi pengalaman hidup remaja di wilayah perkotaan dan perdesaan. Penelitian kualitatif ini menggunakan orientasi fenomenologi interpretatif dalam paradigma konstruktivis dan dilaksanakan di Luwu Raya, Sulawesi Selatan, pada Maret hingga Agustus 2025. Remaja berusia 13–19 tahun tanpa diagnosis DMT2 atau risiko klinis yang teridentifikasi direkrut menggunakan teknik purposive maximum-variation sampling berdasarkan tempat tinggal dan strata sosial ekonomi. Wawancara mendalam semi-terstruktur dilakukan menggunakan bahasa atau dialek pilihan peserta dan dianalisis dengan analisis tematik reflektif, sedangkan kecukupan sampel ditentukan berdasarkan information power. Tujuh tema ditemukan, yaitu makan bersama keluarga dan pengaruh orang tua; praktik pangan tradisional dan kearifan lokal; media sosial dan tren diet yang dipengaruhi teman sebaya; aktivitas fisik dan resistensi; literasi kesehatan dan akses pelayanan kesehatan; keterjangkauan dan ketersediaan pilihan makanan sehat; serta pola tidur dan waktu layar. Praktik pangan keluarga berperan protektif, sedangkan pengaruh teman sebaya, lingkungan digital, dan kondisi lingkungan sering membatasi pilihan sehat. Oleh karena itu, pencegahan DMT2 yang efektif perlu mengintegrasikan strategi berbasis keluarga, lingkungan yang mendukung, serta pendekatan yang responsif terhadap budaya dan selaras dengan prinsip Islam tentang moderasi, pemeliharaan kesehatan, dan tanggung jawab kolektif keluarga.

Graphical Abstract



Keyword

adolescent; diabetes mellitus; feeding behavior; health literacy; social media

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INTRODUCTION

Adolescence is a critical period for establishing dietary, physical-activity, sleep, and digital-use patterns that can influence metabolic health across the life course. This issue has become increasingly important as adolescents are growing up within food environments characterised by instant foods, on-demand delivery services, sugar-rich foods and beverages, and intensive digital food marketing that can normalise unhealthy consumption (A. Chung et al., 2021; S. J. Chung et al., 2017). Traditional diets and home-prepared meals now coexist with commercially prepared and highly processed foods, reflecting a broader nutritional and behavioural transition rather than merely changes in individual preference. At the same time, sedentary behaviour, obesogenic environments, and changing family and social circumstances may contribute to metabolic risk during adolescence (Cabanas-Sánchez et al., 2020; Lascar et al., 2018; Zainuddin et al., 2023). These challenges are directly relevant to Sustainable Development Goal 3, particularly the commitment to reduce premature mortality from non-communicable diseases through prevention and health promotion.

The urgency of prevention is reinforced by the increasing global burden of youth-onset type 2 diabetes mellitus (T2DM). Between 1990 and 2021, the global incidence of T2DM among people aged 15–24 years more than doubled, from 56.0 to 123.9 per 100,000 population, with particularly marked increases among adolescents aged 15–19 years (Deng et al., 2025; Zhou et al., 2025). Youth-onset T2DM is also associated with a more aggressive clinical trajectory than adult-onset disease, including rapid deterioration of beta-cell function and earlier microvascular complications (Nadeau et al., 2016; Zeitler et al., 2012). In Indonesia, geographical variation in diabetes prevalence and the contribution of obesity and hypertension further indicate that prevention should be sensitive to local social and environmental conditions (Oktora & Butar, 2022).

The central challenge in adolescent T2DM prevention is therefore not simply insufficient health knowledge but the way preventive behaviours are shaped and negotiated within family, social, cultural, digital, and environmental contexts. Adolescents do not make food and lifestyle decisions independently of their surroundings. Families influence food purchasing and preparation, meal routines, pocket money, physical activity, screen use, and exposure to particular dietary practices. Home food availability and parental modelling are associated with adolescent

dietary intake, while parental control and parent–adolescent co-decision-making can influence everyday food choices (Loth et al., 2016; Ma & Hample, 2018). A systematic review of qualitative evidence further identified parental education, parenting style, food preferences, family motivation, home meals, food availability, time, cost, and practical knowledge as important pathways through which families shape adolescent eating behaviours (Yee et al., 2021). Consequently, effective T2DM prevention requires approaches that extend beyond individual education toward family-based and socially supportive environments that enable adolescents to translate health knowledge into sustainable preventive practices.

The social-ecological model offers an appropriate framework for understanding these multidimensional influences because it conceptualises health behaviour as the product of interactions across individual, interpersonal, community, organisational, and broader cultural and environmental levels (McLeroy et al., 1988; Ewald et al., 2023). This perspective complements, but extends beyond, individual-cognition models such as the Health Belief Model and Theory of Planned Behaviour, which emphasise perceived susceptibility, beliefs, behavioural intentions, and individual motivation (Orji et al., 2012; Hagger & Hamilton, 2025; Cooke et al., 2026). Although these cognitive mechanisms remain relevant, they may not sufficiently explain adolescent preventive behaviour when healthy choices depend on household food availability, parental rules, financial resources, peer relationships, or the physical environment.

Family-based practices therefore represent an important potential intervention pathway. Shared meals, parental modelling, food procurement, household rules, and parent–adolescent decision-making can create conditions that either facilitate or constrain healthier behaviours. Simultaneously, prevention must consider environmental pressures beyond the household. Adolescents are increasingly exposed to commercial food promotion, social-media trends, easily accessible sugar-rich products, and environments that may provide limited opportunities for physical activity. Individual-level interventions may therefore have limited effectiveness when unhealthy dietary and sedentary practices are normalised within everyday environments (Barry et al., 2025; Lascar et al., 2018). Strategies addressing T2DM prevention should consequently integrate health literacy with supportive family practices, peer and digital

environments, affordable healthy food options, and accessible opportunities for physical activity.

Despite increasing attention to adolescent metabolic risk, an important gap remains between knowledge of risk factors and understanding how prevention is experienced in everyday life. Much of the existing literature has focused on associations between lifestyle behaviours, risk perception, obesity, and diabetes outcomes, whereas fewer studies have examined how adolescents interpret and negotiate preventive practices within their social environments. Particularly limited attention has been given to the combined influence of family food culture, traditional food practices, peer relationships, digital exposure, economic constraints, and urban–rural environments. This limitation is especially relevant in Eastern Indonesia, where traditional household practices coexist with rapidly changing commercial and digital food environments and where opportunities for healthy eating and physical activity may vary considerably between urban and rural communities.

The present study addresses this gap by examining T2DM prevention as a socially negotiated practice rather than solely an outcome of individual knowledge or motivation. Its novelty lies in exploring adolescents who have neither a clinical T2DM diagnosis nor identified clinical risk and in situating their experiences within family, cultural, digital, socioeconomic, and urban–rural contexts. Accordingly, this study aims to explore how adolescents aged 13–19 years in Luwu Raya, South Sulawesi, perceive, negotiate, and enact T2DM prevention; to identify family, social, cultural, and environmental factors that enable or constrain preventive behaviours; and to examine how traditional and contemporary food practices are incorporated into adolescents' everyday lives. These insights are intended to inform contextually appropriate family- and community-based strategies for preventing T2DM before clinical risk becomes established.

METHODS

Study design

Guided by an interpretive phenomenological orientation within a constructivist paradigm, this study explored how adolescents in urban and rural eastern Indonesia perceive, negotiate, and enact T2DM prevention in everyday life. The paradigm recognises meaning as co-constructed between participants and researchers rather than as fixed reality to be discovered, an assumption consistent with the aim of

understanding lived experience rather than measuring it. Fieldwork was conducted between March and August 2025.

Setting and participants

The study was conducted across five districts in Luwu Raya, South Sulawesi, Indonesia: Palopo City (urban) and East Luwu, North Luwu, Toraja, and Luwu (predominantly rural). Participants were adolescents aged 13–19 years without a clinical diagnosis or identified clinical risk of T2DM. Purposive maximum-variation sampling was used to capture variation in age, sex, district, urban–rural residence, and socioeconomic stratum (middle and lower) from a larger descriptive-study cohort. Fifteen adolescents participated (8 boys and 7 girls). Participant characteristics are presented in Table 1 in the Results section. Written informed consent was obtained from participants aged 18–19 years, while participants younger than 18 years provided adolescent assent alongside parental consent.

Researcher characteristics and reflexivity

The research team comprised four researchers with backgrounds in public health management, social epidemiology, and nutrition, each with substantial qualitative research experience in NCD-focused. This prior involvement gave the team an informed pre-understanding of adolescent health behaviour and diabetes prevention, an inevitable, and from a hermeneutic phenomenological standpoint productive, starting point for interpretation rather than a defect to be eliminated. Reflexivity was therefore approached as a disciplined practice for surfacing and examining pre-understanding, not for erasing it.

Before and after each interview, interviewers recorded personal feelings, expectations, and evolving interpretations in a reflective journal. Throughout data collection and analysis, the team held regular debriefings to examine how researchers' professional identities, as public health worker, anthropologist, and nutritionist, might have shaped what participants were willing to share and how researchers were inclined to hear it. Attention was given to power asymmetries between adult researchers and adolescent participants: interviews were conducted in the language or dialect participants preferred and in settings of their choosing, participants were repeatedly reassured that there were no right or wrong answers, and researchers refrained from correcting or evaluating participants' beliefs during interviews.

Table 1
Participants Details

Participant	Age	Sex	Location	Education
P01	18	Female	Urban	University
P02	19	Male	Rural	University
P03	14	Female	Rural	Junior High
P04	15	Male	Urban	Senior High
P05	13	Female	Rural	Junior High
P06	16	Male	Urban	Senior High
P07	15	Female	Rural	Senior High
P08	14	Male	Urban	Junior High
P09	16	Female	Rural	Senior High
P10	17	Male	Urban	Senior High
P11	15	Female	Rural	Senior High
P12	14	Male	Urban	Junior High
P13	16	Female	Rural	Senior High
P14	13	Male	Urban	Junior High
P15	16	Female	Rural	Senior High

Data collection

Data were generated through semi-structured, in-depth interviews conducted by the first and second researchers, both trained in qualitative techniques. An interview guide with open-ended questions covered domains including everyday food practices, understandings of diabetes and its risks, family food culture and household mealtime routines, use of digital media and food-delivery services, and support systems perceived to enable or hinder healthy routines. After the first several interviews, the team reviewed emerging content and refined prompts to explore areas of interest that had surfaced; adjustments were discussed with the third and fourth researchers to ensure interpretive consistency.

Interviews lasted 60–100 minutes and were audio-recorded with informed consent. Where deeper exploration was warranted, follow-up sessions were arranged with the same participant. Interviewers used active listening and neutral probes (e.g., "can you tell me more about that?"), and participants were assured they could decline to discuss any topic. Field notes captured the interview setting, home and neighbourhood environment, non-verbal expression, and post-interview impressions.

Recruitment and interviewing continued until information (Malterud et al., 2016) was judged adequate, that is, until the accumulated material was sufficiently rich, diverse, and dense to address the study aims given the specificity of the sample, the quality of dialogue, and the interpretive orientation of analysis. In practical terms this occurred after 12 interviews; 3 more additional interviews were

conducted to confirm that no substantially new perspectives were emerging.

Data processing and analysis

Interviews were transcribed verbatim in the original language or dialect. Local-language passages were retained in the working transcripts and translated into English by a bilingual member of the research team familiar with the local context. Idiomatic and culturally specific expressions were discussed with the interviewer and research team to agree on contextual meaning. Selected quotations were back-translated to assess conceptual fidelity, and discrepancies were resolved through team discussion. The third and fourth researchers cross-checked transcripts against audio recordings.

Data were analysed using reflexive thematic analysis following Braun and Clarke (2006, 2019), consistent with the study's constructivist and interpretive orientation. The first two researchers independently read and inductively coded transcripts, after which the four researchers compared interpretations and developed candidate themes. NVivo 12 supported data organisation. Themes were iteratively reviewed against transcripts and field notes, with alternative interpretations discussed during team meetings. Reflexive team discussion and triangulation were used to strengthen interpretive rigour rather than inter-rater reliability.

Ethical considerations

The study was approved by the Research Ethics Committee of Nani Hasanuddin Institute (No. 367/STIKES-NH/KEPK/VI/2025). Participants received

Table 2
Main themes, subthemes, and quotes from informants

Theme	Subthemes and Quotes
Theme 1: Family Meals and Parental Influence (Context of Eating at Teens' Home)	– Family mealtimes (shared routines and rules): "Our family always eats dinner together, without cell phones." (Female, 18) – Parental guidance on diet (monitoring and reminders): "My mother often reminds me to cut back on sugar." (Female, 16)
Theme 2: Traditional Food Practices and Local Wisdom (Cultural Eating Habits)	– Use of traditional dishes (especially at family events): "We always serve traditional Luwu dishes – these dishes are considered healthier and have symbolic meaning." (Male, 18 years old) – Perception of the health of local foods (natural, high fiber) compared to modern snacks. (Participants considered traditional home-cooked vegetables and rice healthier than instant, western, or viral fast food.)
Theme 3: Social Media and Peer-Driven Diet Trends (Modern influences on diet)	– Normalization of sugary drinks/snacks (high-frequency intake): "I drink sugary iced drinks almost every day, about 3–4 times." (Male, 15 years old) – "Viral" food trends and peer pressure (trying trendy snacks/drinks due to social influence): "If there's something that's trending on TikTok, I feel like I should try it at least once." (Female, 16 years old)
Theme 4: Physical Activity: Intention vs. Resistance (Exercise habits and barriers)	– Intention-behavior gap (exercise plan vs. "laziness"): "I want to exercise, but I often get too lazy when I'm on my phone." (Male, 16 years old) – Psychosocial barriers (shyness, low confidence): "I feel too embarrassed to exercise when the place is crowded." (Female, 15 years old)
Theme 5: Health Literacy and Access to Health Services (Involvement in preventive health efforts)	– Risk awareness but low proactive action: "I once checked my blood sugar, when there was a free health event on my campus." (Male, 19 years old) – Reliance on outreach services (waiting for screening at school or community rather than self-checking). (Few youth seek preventive counseling unless it is brought to their immediate ward.)
Theme 6: Cost and Availability of Healthy Options (Environment and food resources)	– Cheap unhealthy foods vs. expensive healthy choices: "Sugary snacks and cold drinks are cheap – but fruits are quite expensive." (Male, 15 years old) – Resource gap (lack of affordable sports facilities, especially in rural areas). (Urban youth say gyms are expensive or crowded, while rural youth have limited facilities nearby.)
Theme 7: Sleep Patterns and Screen Time (Lifestyle Routines)	– Late-night screen use (affecting rest time and energy): "To be honest, I often stay up late while scrolling through my phone screen." (Male, 16 years old) – Lack of sleep and fatigue (resulting in low activity in the morning): (Many teens admit that sleeping late at night makes them too tired to do activities the next day.)

information about the study, confidentiality, voluntary participation, and their right to withdraw. Interviews were conducted in private locations selected with participants to minimise discomfort and protect confidentiality. Participants could decline any question or stop the interview at any time. Particular care was taken when discussing potentially sensitive topics, including body image, family relationships, and peer pressure; interviewers used non-judgmental communication and paused or discontinued questioning if participants showed signs of discomfort or distress. For participants younger than 18 years, parental consent and adolescent assent were obtained. Identifying information was removed from transcripts and pseudonyms were used in reporting.

RESULTS

To achieve the goal of the study, which is to uncover the most meaningful things for adolescents in recognizing the risks and how the role of family, local food, eating habits, and home meals can be social capital for the prevention of T2DM, the team conducted in-depth interviews with adolescents aged 13–19 years in the Luwu Raya area (urban-rural).

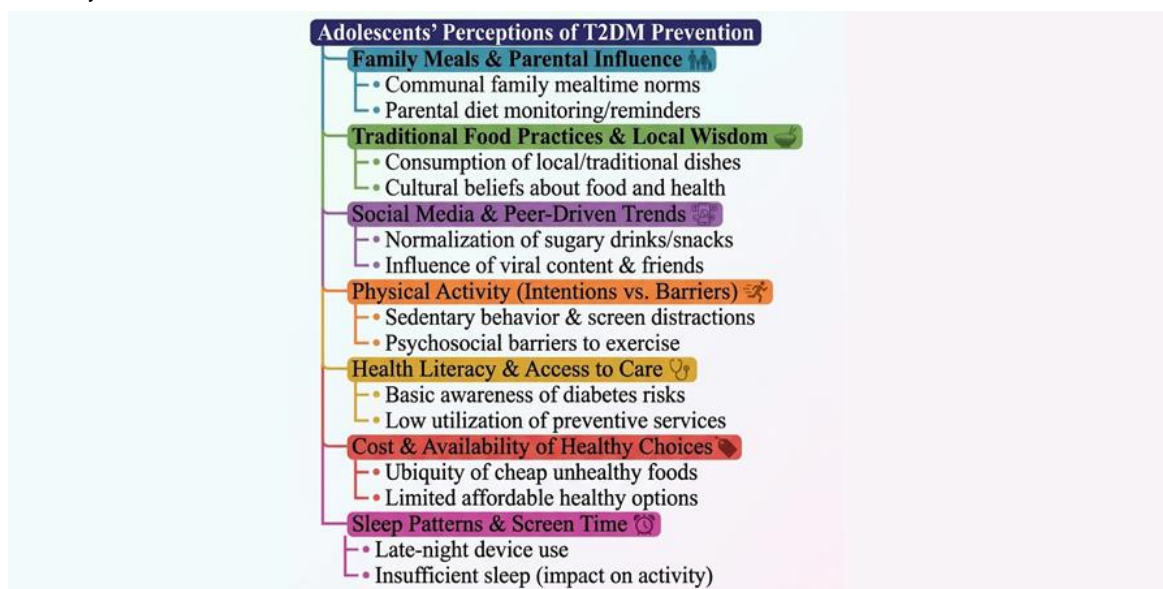
Through the interview, data processing, and triangulation process, the team identified seven main themes from the interview, each with several subthemes (see Table 1). These themes include eating habits, sociocultural influences, and lifestyle factors related to the risk of type 2 diabetes. Table 2 presents a summary of each theme and subtheme along with illustrative quotes from the participants.

Qualitative data is also visualized to aid in interpretation. Figure 1 illustrates a hierarchical thematic tree of the main theme and subtheme, showing the hierarchy of the main themes and subthemes identified from the results of a qualitative analysis of adolescents' perceptions of the prevention of type 2 diabetes (T2DM).

Thematic analysis identified seven themes: (1) Family Meals and Parental Influence, (2) Traditional Food Practices and Local Wisdom, (3) Social Media and Peer-Driven Diet Trends, (4) Physical Activity: Intention vs. Resistance, (5) Health Literacy and Access to Health Services, (6) Cost and Availability of Healthy Options, and (7) Sleep Patterns and Screen Time. Each major theme has several subthemes that reveal specific dimensions of adolescent experiences and perceptions, such as the normalization of sugary

Figure 1

Hierarchy of identified themes and subthemes



food consumption, psychosocial barriers to exercise, and the importance of family influence in dietary arrangements. This structure provides a comprehensive understanding of the contextual, social, and cultural factors that influence T2DM prevention behaviors in adolescents.

Table 3 shows the frequency of occurrence of each of the main themes in repeated interviews with 15 adolescent informants. All seven themes appeared across the participant accounts, although their frequency varied. Social Media and Peer-Driven Diet Trends and Physical Activity: Intention vs. Resistance were mentioned by all 15 participants (15/15). Family Meals and Parental Influence appeared in 14 of 15 accounts, followed by Cost and Availability of Healthy Options (13/15) and Traditional Food Practices and Local Wisdom (12/15). Sleep Patterns and Screen Time appeared in 11/15 accounts, while Health Literacy and Access to Health Services appeared in 10/15 accounts. These frequencies are presented descriptively to show the recurrence of themes across participant accounts and are not interpreted as measures of prevalence, statistical significance, or thematic importance. Interpretation therefore considered not only how frequently a theme was mentioned but also the depth, diversity, and contextual meaning of participants' narratives.

DISCUSSION

The This study explored how adolescents in Luwu Raya and the Toraja region of South Sulawesi perceive, negotiate, and enact T2DM prevention within

their everyday social and cultural environments. Seven interconnected themes were identified: Family Meals and Parental Influence; Traditional Food Practices and Local Wisdom; Social Media and Peer-Driven Diet Trends; Physical Activity: Intention vs. Resistance; Health Literacy and Access to Health Services; Cost and Availability of Healthy Options; and Sleep Patterns and Screen Time. Viewed through the social-ecological model (McLeroy et al., 1988) and a social practice perspective (Blue et al., 2016), the findings indicate that adolescent preventive behaviors are influenced by individual knowledge alongside familial, social, cultural, and environmental factors.

Family and cultural practices as anchors of prevention

Family Meals and Parental Influence emerged as an important interpersonal context shaping adolescents' everyday food practices. Participants described shared meals, parental reminders, and household routines as influencing what and how they ate. This finding is consistent with evidence that shared family meals are associated with healthier dietary patterns and lower obesity risk among adolescents (Snuggs & Harvey, 2023), while home-cooked meals have also been identified as important facilitators of healthy eating among young people (Liu et al., 2021). Importantly, participants generally described these practices as ordinary family routines rather than deliberate health interventions. Thus, family may represent a practical and culturally embedded entry point for adolescent T2DM prevention.

Table 3
The frequency of the theme appearing in the informant per interview session

Theme	Appearance/mentions in repeated interview
Family/Parental Influence	14/15
Traditional Food Practices	12/15
Social Media Trends	15/15
Physical Activity Barriers	15/15
Health Literacy/Access	10/15
Cost/Availability	13/15
Sleep/Screen Time	11/15

Traditional Food Practices and Local Wisdom further demonstrated that food choices were embedded in cultural and familial contexts. Participants associated traditional and home-cooked foods with familiarity, naturalness, and perceived healthiness, while traditional dishes also retained symbolic meaning during family events. Previous Indonesian research has shown that traditional staple foods remain relevant to adolescent diets, particularly outside major metropolitan areas, and may be more affordable than branded fast foods (Briawan et al., 2023). This coexistence of traditional and modern food practices suggests that prevention need not replace existing food culture but could build upon familiar foods and household practices. Culturally tailored strategies have also been shown to support engagement in adolescent NCD prevention across different populations (Sanders et al., 2015). However, cultural adaptation should remain sensitive to the specific meanings and practices of the Luwu and Toraja contexts rather than transferring models developed elsewhere without contextual examination.

These findings are particularly relevant from a family-health perspective. Food procurement, meal routines, parental guidance, and opportunities to eat together are largely organised within households. Consequently, adolescents' ability to act on prevention messages is partly dependent on what food is available at home, how meals are organised, and how parents and other family members model eating behaviours. Family-based prevention may therefore be more appropriate than interventions that position adolescents as solely responsible for dietary change.

Peer relations and digital media as competing influences

Social Media and Peer-Driven Diet Trends represented a contrasting influence on adolescents' food practices. Participants described sugary drinks, snacks, and viral foods as familiar elements of social interaction. The consumption of sugar-sweetened

beverages appeared to be normalised not only through taste preferences but also through participation in peer activities and exposure to digital trends. Similar qualitative evidence has shown that sugar-sweetened beverages can become socially normalised among adolescents (Lems et al., 2019).

A social practice perspective helps explain why health knowledge alone may not be sufficient to alter these behaviours. Eating practices are connected to social meanings, competencies, and material resources (Blue et al., 2016; Liu et al., 2022). In this context, refusing a popular food or drink may involve social costs because consumption is associated with belonging and participation. The problem is therefore not simply whether adolescents know that excessive sugar is unhealthy, but whether healthier alternatives are compatible with the social situations in which eating occurs.

The material and digital environment may further strengthen these practices. The ready availability and low cost of energy-dense foods and sugar-sweetened beverages can reduce practical barriers to consumption (Nguyen et al., 2023; Pepping et al., 2025). At the same time, social media exposes adolescents to food-related marketing and consumption-oriented content at high frequency (von Philipsborn et al., 2019). These influences suggest that interventions focused exclusively on individual willpower may be insufficient. Prevention should also consider the social meanings, availability, affordability, and digital visibility of foods.

Urban–rural differences in the prevention environment

The findings also demonstrate that the context in which adolescents live shapes how T2DM prevention can be enacted. Urban and predominantly rural participants shared several influences, particularly family, peer, and digital influences, but described

different combinations of environmental opportunities and constraints.

Urban participants described greater access to commercial food outlets and recreational facilities, while cost and crowding could limit access to healthier food choices or formal opportunities for physical activity. In predominantly rural settings, participants described fewer nearby recreational facilities and greater reliance on household and locally available foods. Thus, rural settings should not automatically be interpreted as healthier environments, nor urban settings as uniformly less healthy. Rather, adolescents in both settings experience different configurations of access, availability, affordability, and social influence.

This pattern is consistent with the broader concept that food environments shape dietary behaviour through the availability and accessibility of food choices (Downs & Demmler, 2020; Imoisili et al., 2020). Research also indicates that food price and availability are important determinants of adolescent food choice (Briawan et al., 2023; Mesch et al., 2025). The present findings extend this understanding by showing how these structural conditions are experienced and interpreted by adolescents themselves.

Physical activity showed a similar urban–rural asymmetry. Urban participants described gyms or other formal facilities as available but sometimes expensive or crowded, whereas rural participants described more limited access to nearby facilities. These findings suggest that the same recommendation to “exercise regularly” may carry different practical constraints depending on place. Rather than applying a uniform intervention, prevention programmes should consider locally available spaces, costs, safety, and social acceptability of physical activity.

The concept of “food deserts” or “activity deserts,” developed largely within North American public health contexts, may not fully capture these patterns. As Lane and Davis (2022) suggest, food and activity environments need to be interpreted in relation to their broader social and geographical contexts. In Luwu Raya and the Toraja region, the findings point instead to differently constrained food and activity environments, in which adolescents may have either an abundance of commercial food choices or limited access to recreational resources, depending on their setting.

Individual meanings and intention–behaviour gap

At the individual level, participants generally demonstrated basic knowledge about T2DM

prevention. They could identify vegetables and traditional foods as healthy, recognise the importance of physical activity, and associate excessive sugar consumption with diabetes. Nevertheless, this knowledge did not consistently translate into behaviour. This finding supports the social practice perspective that knowing what is healthy is different from being able to enact healthier practices within everyday routines (Blue et al., 2016).

The Physical Activity: Intention vs. Resistance theme illustrates this gap particularly clearly. Participants expressed an intention to exercise but described competing smartphone use, lack of motivation, shyness, and low confidence as barriers. Girls in particular described discomfort exercising in crowded environments. Previous evidence indicates that body image and gender-related concerns can influence physical activity among adolescents, particularly girls (van Sluijs et al., 2021). These findings suggest that interventions should consider the social setting in which physical activity takes place rather than treating low activity solely as a problem of motivation.

Health Literacy and Access to Health Services represented a related but somewhat different issue. Participants showed awareness of diabetes risk but often described accessing screening or health information when these services were provided through schools or community activities. This suggests that adolescents may have limited motivation or opportunity to seek preventive services independently. Bringing preventive services into settings already used by adolescents may therefore be more feasible than relying on individual self-initiated healthcare seeking.

Sleep patterns and screen time as interconnected practices

Sleep Patterns and Screen Time emerged as another lifestyle dimension connected to several other themes. Participants described staying up late using smartphones and subsequently experiencing tiredness or reduced activity the following day. This finding is consistent with evidence linking prolonged screen time and insufficient sleep with adverse cardiometabolic outcomes among adolescents (Nagata et al., 2023; Sivanesan et al., 2020).

From a social practice perspective, screen use, sleep, food-related media exposure, and physical inactivity should not necessarily be treated as separate behavioural problems. They may form part of a connected daily routine in which late-night digital engagement displaces sleep and physical activity while

simultaneously increasing exposure to food-related content. This interconnectedness suggests that interventions targeting adolescent routines may be more useful than addressing each behaviour independently.

Implications for family and community-grounded prevention

Taken together, the findings suggest that adolescent T2DM prevention in Luwu Raya and the Toraja region should move beyond individual health education toward interventions that engage families, peers, communities, and the surrounding material environment. The family represents a particularly important entry point because parents and household members influence food procurement, meal routines, dietary guidance, and everyday modelling. Strengthening shared meals and adapting familiar traditional foods toward healthier preparation may therefore provide a culturally acceptable foundation for prevention.

At the peer and community levels, prevention could work with rather than against existing social networks. The same digital and peer channels that contribute to the normalisation of sugary foods may also provide opportunities to make healthier practices socially visible and acceptable. Evidence concerning adolescent food environments suggests that improving the availability and affordability of healthier choices is important alongside educational strategies (Nguyen et al., 2023; Pepping et al., 2025).

The urban–rural findings further indicate that interventions should be context-sensitive. Urban strategies may need to address the high accessibility of commercially prepared foods and barriers to affordable recreational facilities, whereas rural strategies may place greater emphasis on strengthening existing household and local food practices while improving access to safe and feasible physical-activity opportunities. Such strategies are consistent with an ecological understanding of health behaviour in which individual practices are shaped by interpersonal, community, and structural conditions (McLeroy et al., 1988).

Importantly, these implications should not be interpreted as evidence that any particular intervention will reduce T2DM incidence. Rather, they identify potential intervention points emerging from adolescents' accounts. Future intervention studies should determine whether family-based, peer-oriented, digital, food-environment, or context-specific physical-

activity strategies produce measurable changes in adolescent health behaviours and metabolic risk.

Study boundary and interpretive considerations

The strength of this study lies in its exploration of how adolescents make sense of T2DM prevention within their everyday social and cultural environments. The findings illustrate the interaction between family practices, cultural food traditions, peer and digital influences, physical activity, health literacy, economic conditions, and sleep routines. The frequency of themes should be understood as an indication of recurrence across participant accounts rather than as a measure of prevalence, statistical importance, or causal influence.

The findings are also bounded by the purposive sample of 15 adolescents and the specific geographical and cultural contexts of Luwu Raya and the Toraja region. The urban–rural differences identified should therefore be interpreted as contextual patterns rather than population-level comparisons. Further research involving larger and more diverse samples could examine whether these patterns are transferable to other regions of Indonesia.

Finally, although religious concepts were not explicitly generated as empirical themes from participants' accounts, the findings may still be situated within an Islamic ethical framework at the interpretive level, provided that this distinction is clearly maintained. In this study, Islamic values are therefore not treated as explanatory constructs derived from the empirical data, but rather as a complementary normative perspective for interpreting the broader implications of adolescent T2DM prevention. Several findings, particularly those related to food practices, moderation, family responsibility, and avoidance of excessive consumption, are conceptually consistent with the Islamic principles of *halal-thayyib*, moderation, and stewardship of health. The Qur'an, in Surah Al-Baqarah verse 168, encourages the consumption of food that is both lawful and good:

“...Eat of what is lawful and good on the earth ...”

This principle is complemented by the prohibition of excessive consumption in Surah Al-A'raf verse 31:

“... Eat and drink, but do not be excessive ...”

From this perspective, healthy eating may be understood not only as a biomedical recommendation but also as an ethical commitment to consuming food that is lawful, wholesome, safe, and beneficial, while

avoiding excessive dietary practices that may contribute to obesity and long-term metabolic risk. The concepts of *halal-thayyib* and avoidance of *israf* therefore provide a normative foundation that is compatible with preventive behaviours related to balanced dietary intake and the maintenance of metabolic health.

The family dimension of T2DM prevention can likewise be interpreted through the Islamic principle of responsibility for the well-being of household members. Surah At-Tahrim verse 6 emphasises the responsibility of individuals toward themselves and their families:

“... *Protect yourselves and your families ...*”

Within the context of family health, this principle may be interpreted as supporting parental and household responsibility for creating environments that protect family members from preventable health risks. This interpretation is consistent with the present study's findings that family meals, parental guidance, household food availability, and daily routines can function as protective resources for adolescents. Furthermore, a Prophetic teaching narrated in *Sahih al-Bukhari*, Hadith No. 5199, emphasises an individual's responsibility toward bodily well-being:

“*Your body has a right over you.*”

This teaching provides an ethical basis for maintaining health through balanced food consumption, adequate rest, appropriate physical activity, and avoidance of harmful excess. Accordingly, Islamic integration in adolescent T2DM prevention should not be presented as an assumed determinant of participants' behaviour, but rather as a culturally and ethically relevant framework that may inform future health-promotion strategies. Future research should therefore empirically explore how adolescents and their families understand and apply the concepts of *halal-thayyib*, moderation (*wasatiyyah*), avoidance of excess (*israf*), and responsibility for bodily and family well-being, and whether these values can strengthen family-based and community-supported approaches to T2DM prevention.

The limitations of this study arise primarily from its interpretive and context-specific design. Reflexive thematic analysis produces researcher-generated interpretations rather than objective classifications, and the research team's prior involvement in NCD interventions may have influenced both data collection and interpretation (Braun & Clarke, 2019). Reflexive journaling, team debriefing, and attention to

researcher-participant power relations were used to make these influences visible, although they could not be eliminated. The sample was also small and geographically specific, comprising 15 adolescents from five districts of Greater Luwu. Maximum-variation purposive sampling across urban-rural residence and socioeconomic strata was intended to achieve information power rather than statistical generalisation (Malterud et al., 2016), and higher-income adolescents were not represented.

The study also relied entirely on adolescent self-report, which may have been influenced by social desirability, particularly for behaviours such as sugar-sweetened beverage consumption, late-night screen use, and disagreement with parental guidance. Interviews were conducted largely at single time points, limiting the ability to capture changes across school periods, ceremonial cycles, or evolving digital exposure. Translation from local languages and dialects into English may also have reduced some tonal and cultural nuance despite back-translation of representative quotations. Finally, the study did not objectively measure dietary intake, physical activity, sleep, or metabolic markers and therefore cannot establish causal relationships between reported practices and future T2DM risk. The rapidly changing digital and food-retail environment further limits the durability of platform- or product-specific observations, although the broader behavioural dynamics identified may remain relevant over time.

CONCLUSIONS

Adolescent type 2 diabetes mellitus (T2DM) prevention in Luwu Raya and the Toraja region is shaped by interconnected family, cultural, peer, digital, and environmental influences rather than by individual health knowledge alone. Family meals, parental guidance, household food practices, peer norms, digital food exposure, food affordability, physical-activity opportunities, screen use, and sleep collectively influence preventive behaviours. Family-based practices provide an important entry point through shared meals, parental modelling, and household routines, but these efforts must be supported by broader strategies addressing peer influence, digital environments, healthy food access, and opportunities for physical activity. Prevention should therefore combine family-anchored and community-supported approaches that are sensitive to urban-rural differences and compatible with Islamic values of moderation, health stewardship, avoidance of

excess, and collective responsibility for family well-being. Future research should develop and evaluate culturally adapted, family-centred interventions using longitudinal or controlled designs to determine their effectiveness and sustainability across diverse urban and rural settings. Particular attention should be given to identifying the most influential intervention components, exploring differences by socioeconomic and cultural context, and assessing changes not only in dietary, physical-activity, screen-use, and sleep behaviours but also in objective metabolic indicators and longer-term T2DM risk.

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AUTHORS' CONTRIBUTIONS

Achmad R. Muttaqien Al-Maidin: Conceptualization, study design, data acquisition and analysis, and writing—original draft, review, and editing. Zamli: Participant recruitment, data collection and analysis, and writing—original draft. Musni: Conceptualization, participant recruitment, data acquisition, and data analysis. Azniah Syam: Conceptualization, field investigation, and writing—review and editing. Pupin Astuti: Field investigation and writing—review and editing. All authors critically reviewed the manuscript, approved the final version, and agreed to be accountable for the content of the work.

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COMPETING INTERESTS

The author(s) declare no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

Barry, E., Greenhalgh, T., Papoutsis, C., Shaw, S. E., Ferrey, A., & Rutter, H. (2025). Preventing type 2 diabetes: a qualitative study exploring the complexity of health-related practices in people with prediabetes. *British Journal of General Practice*, 75(760), e739–e748. <https://doi.org/10.3399/BJGP.2025.0208>

Blue, S., Shove, E., Carmona, C., & Kelly, M. P. (2016). Theories of practice and public health: understanding (un)healthy practices. *Critical Public Health*, 26(1), 36–50. <https://doi.org/10.1080/09581596.2014.980396>

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp0630a>

Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health*, 11(4), 589–597. <https://doi.org/10.1080/2159676X.2019.1628806>

Briawan, D., Khomsan, A., Alfiah, E., Nasution, Z., & Putri, P. A. (2023). Preference for and consumption of traditional and fast foods among adolescents in Indonesia. *Food Research*, 7(4), 211–226. [https://doi.org/10.26656/fr.2017.7\(4\).156](https://doi.org/10.26656/fr.2017.7(4).156)

Cabanas-Sánchez, V., Esteban-Cornejo, I., Izquierdo-Gómez, R., Padilla-Moledo, C., Castro-Piñero, J. and Veiga, Ó.L. (2020), How socio-demographic and familiar circumstances are associated with total and domain-specific sedentary behaviour in youth? The UP&DOWN study. *European Journal of Sport Science*, 20: 1102-1112. <https://doi.org/10.1080/17461391.2019.1691271>

Cabanas-Sánchez, V., García-Cervantes, L., Esteban-Gonzalo, L., Girela-Rejón, M. J., Castro-Piñero, J., & Veiga, Ó. L. (2020). Social correlates of sedentary behavior in young people: The UP&DOWN study. *Journal of Sport and Health Science*, 9(2), 189–196. <https://doi.org/10.1016/j.jshs.2019.03.005>

Chung, A., Vieira, D., Donley, T., Tan, N., Jean-Louis, G., Kiely Gouley, K., & Seixas, A. (2021). Adolescent Peer Influence on Eating Behaviors via Social Media: Scoping Review. *Journal of Medical Internet Research*, 23(6), e19697. <https://doi.org/10.2196/19697>

Chung, S. J., Ersig, A. L., & McCarthy, A. M. (2017). The Influence of Peers on Diet and Exercise Among Adolescents: A Systematic Review. *Journal of Pediatric Nursing*, 36, 44–56. <https://doi.org/10.1016/j.pedn.2017.04.010>

Cooke, R., Mabile, G., Adolfsen, F., Koposov, R., & Kyrrestad, H. (2026). Do theory of planned behaviour constructs change during adolescent alcohol use onset? *Substance Abuse Treatment, Prevention, and Policy*, 21(1), 37. <https://doi.org/10.1186/s13011-026-00726-5>

Deng, L., Lu, S., Zeng, J., & Liu, H. (2025). Global, regional, and national trends and burden of diabetes mellitus type 2 among youth from 1990 to 2021: an analysis from the global burden of disease study 2021. *Frontiers in Endocrinology*, 16. <https://doi.org/10.3389/fendo.2025.1626225>

Downs, S., & Demmler, K. M. (2020). Food environment interventions targeting children and adolescents: A scoping review. *Global Food Security*, 27, 100403. <https://doi.org/10.1016/j.gfs.2020.100403>

Ewald, D. R., Orsini, M. M., & Strack, R. W. (2023). The path to good health: Shifting the dialogue and promoting social ecological thinking. *SSM - Population Health*, 22, 101378. <https://doi.org/10.1016/j.ssmph.2023.101378>

Hagger, M. S., & Hamilton, K. (2025). Progress on theory of planned behavior research: advances in research synthesis and agenda for future research. *Journal of Behavioral Medicine*, 48(1), 43–56. <https://doi.org/10.1007/s10865-024-00545-8>

Imoisili, O. E., Park, S., Lundeen, E. A., Yaroch, A. L., & Blanck, H. M. (2020). Daily Adolescent Sugar-Sweetened Beverage Intake Is Associated With Select Adolescent, Not Parent, Attitudes About Limiting Sugary Drink and Junk Food Intake. *American Journal of Health Promotion*, 34(1), 76–82. <https://doi.org/10.1177/0890117119868382>

Lane, J. M., & Davis, B. A. (2022). Food, physical activity, and health deserts in Alabama: the spatial link between healthy eating, exercise, and socioeconomic factors. *GeoJournal*, 87(6), 5229–5249. <https://doi.org/10.1007/s10708-021-10568-2>

Lascar, N., Brown, J., Pattison, H., Barnett, A. H., Bailey, C. J., & Bellary, S. (2018). Type 2 diabetes in adolescents and young adults.

- The Lancet Diabetes & Endocrinology*, 6(1), 69–80.
[https://doi.org/10.1016/S2213-8587\(17\)30186-9](https://doi.org/10.1016/S2213-8587(17)30186-9)
- Lems, E., Hilverda, F., Broerse, J. E. W., & Dedding, C. (2019). 'Just stuff yourself': Identifying health-promotion strategies from the perspectives of adolescent boys from disadvantaged neighbourhoods. *Health Expectations*, 22(5), 1040–1049.
<https://doi.org/10.1111/hex.12913>
- Liu, K. S. N., Chen, J. Y., Ng, M. Y. C., Yeung, M. H. Y., Bedford, L. E., & Lam, C. L. K. (2021). How Does the Family Influence Adolescent Eating Habits in Terms of Knowledge, Attitudes and Practices? A Global Systematic Review of Qualitative Studies. *Nutrients*, 13(11), 3717.
<https://doi.org/10.3390/nu13113717>
- Liu, K. S. N., Chen, J. Y., Sun, K.-S., Tsang, J. P. Y., Ip, P., & Lam, C. L. K. (2022). Adolescent Knowledge, Attitudes and Practices of Healthy Eating: Findings of Qualitative Interviews among Hong Kong Families. *Nutrients*, 14(14), 2857.
<https://doi.org/10.3390/nu14142857>
- Loth, K. A., MacLehose, R. F., Larson, N., Berge, J. M., & Neumark-Sztainer, D. (2016). Food availability, modeling and restriction: How are these different aspects of the family eating environment related to adolescent dietary intake?. *Appetite*, 96, 80–86.
<https://doi.org/10.1016/j.appet.2015.08.026>
- Ma, Z., & Hample, D. (2018). Modeling Parental Influence on Teenagers' Food Consumption: An Analysis Using the Family Life, Activity, Sun, Health, and Eating (FLASHE) Survey. *Journal of nutrition education and behavior*, 50(10), 1005–1014.
<https://doi.org/10.1016/j.jneb.2018.07.005>
- Malterud, K., Siersma, V. D., & Guassora, A. D. (2016). Sample Size in Qualitative Interview Studies: Guided by Information Power. *Qualitative Health Research*, 26(13), 1753–1760.
<https://doi.org/10.1177/1049732315617444>
- McLeroy, K. R., Bibeau, D., Steckler, A., & Glanz, K. (1988). An Ecological Perspective on Health Promotion Programs. *Health Education Quarterly*, 15(4), 351–377.
<https://doi.org/10.1177/109019818801500401>
- Mesch, A., Hoefnagels, F., Gulikers, J., Wesselink, R., Winkens, L. H. H., Raghoobar, S., & Haveman-Nies, A. (2025). The food environment through the eyes of adolescents: exploring socioecological factors and opportunities for healthy and sustainable food choices. *BMC Public Health*, 25(1), 2177.
<https://doi.org/10.1186/s12889-025-23441-5>
- Nadeau, K. J., Anderson, B. J., Berg, E. G., Chiang, J. L., Chou, H., Copeland, K. C., Hannon, T. S., Huang, T. T.-K., Lynch, J. L., Powell, J., Sellers, E., Tamborlane, W. V., & Zeitler, P. (2016). Youth-Onset Type 2 Diabetes Consensus Report: Current Status, Challenges, and Priorities. *Diabetes Care*, 39(9), 1635–1642.
<https://doi.org/10.2337/dc16-1066>
- Nagata, J. M., Lee, C. M., Lin, F., Ganson, K. T., Pettie Gabriel, K., Testa, A., Jackson, D. B., Dooley, E. E., Gooding, H. C., & Vittinghoff, E. (2023). Screen Time from Adolescence to Adulthood and Cardiometabolic Disease: a Prospective Cohort Study. *Journal of General Internal Medicine*, 38(8), 1821–1827.
<https://doi.org/10.1007/s11606-022-07984-6>
- Nguyen, M., Jarvis, S. E., Tinajero, M. G., Yu, J., Chiavaroli, L., Mejia, S. B., Khan, T. A., Tobias, D. K., Willett, W. C., Hu, F. B., Hanley, A. J., Birken, C. S., Sievenpiper, J. L., & Malik, V. S. (2023). Sugar-sweetened beverage consumption and weight gain in children and adults: a systematic review and meta-analysis of prospective cohort studies and randomized controlled trials. *The American Journal of Clinical Nutrition*, 117(1), 160–174.
<https://doi.org/10.1016/j.ajcnut.2022.11.008>
- Oktora, S. I., & Butar Butar, D. (2022). Determinants of Diabetes Mellitus Prevalence in Indonesia. *Jurnal Kesehatan Masyarakat*, 18(2), 266–273.
<https://doi.org/10.15294/kemas.v18i2.31880>
- Orji, R., Vassileva, J., & Mandryk, R. (2012). Towards an effective health interventions design: an extension of the health belief model. *Online Journal of Public Health Informatics*, 4(3).
<https://doi.org/10.5210/ojphi.v4i3.4321>
- Pepping, R., Waterlander, W., Groot, B., Kistemaker, S., Verhoeff, A. P., Seidell, J. C., & Busch, V. (2025). 'Soft drinks are normal': understanding the lived experiences of Dutch teenagers with respect to sugar-sweetened beverages: a qualitative context-mapping study. *BMC Public Health*, 25(1), 925.
<https://doi.org/10.1186/s12889-025-22167-8>
- Sanders, T. V. L., Johnson-Jennings, M., Bauman, A. A., & Proctor, E. (2015). Use of Culturally Focused Theoretical Frameworks for Adapting Diabetes Prevention Programs: A Qualitative Review. *Preventing Chronic Disease*, 12, 140421.
<https://doi.org/10.5888/pcd12.140421>
- Sivanesan, H., Vanderloo, L. M., Keown-Stoneman, C. D. G., Parkin, P. C., Maguire, J. L., & Birken, C. S. (2020). The association between screen time and cardiometabolic risk in young children. *International Journal of Behavioral Nutrition and Physical Activity*, 17(1), 41.
<https://doi.org/10.1186/s12966-020-00943-6>
- Snuggs, S., & Harvey, K. (2023). Family Mealtimes: A Systematic Umbrella Review of Characteristics, Correlates, Outcomes and Interventions. *Nutrients*, 15(13), 2841.
<https://doi.org/10.3390/nu15132841>
- van Sluijs, E. M. F., Ekelund, U., Crochemore-Silva, I., Guthold, R., Ha, A., Lubans, D., Oyeyemi, A. L., Ding, D., & Katzmarzyk, P. T. (2021). Physical activity behaviours in adolescence: current evidence and opportunities for intervention. *The Lancet*, 398(10298), 429–442.
[https://doi.org/10.1016/S0140-6736\(21\)01259-9](https://doi.org/10.1016/S0140-6736(21)01259-9)
- von Philipsborn, P., Stratil, J. M., Burns, J., Busert, L. K., Pfadenhauer, L. M., Polus, S., Holzapfel, C., Hauner, H., & Rehfuss, E. (2019). Environmental interventions to reduce the consumption of sugar-sweetened beverages and their effects on health. *Cochrane Database of Systematic Reviews*, 2019(6).
<https://doi.org/10.1002/14651858.CD012292.pub2>
- Zainuddin, A. A., Rahim, A., Ramadany, S., Dharmayani, H., Kuswanto, H., Kadir, R. R. A., Abdullah, A. A., & Rasyid, H. (2023). Geospatial analysis of type 2 diabetes mellitus and hypertension in South Sulawesi, Indonesia. *Scientific Reports*, 13(1).
<https://doi.org/10.1038/s41598-023-27902-y>
- Zeitler, P., Hirst, K., Pyle, L., Linder, B., Copeland, K., Arslanian, S., Cuttler, L., Nathan, D. M., Tollefsen, S., Wilfley, D., & Kaufman, F. (2012). A clinical trial to maintain glycemic control in youth with type 2 diabetes. *The New England Journal of Medicine*, 366(24), 2247–2256.
<https://doi.org/10.1056/NEJMoa1109333>
- Zhou, Y., Chen, Y., Tang, Y., Zhang, S., Zhuang, Z., & Ni, Q. (2025). Rising tide: the growing global burden and inequalities of early-onset type 2 diabetes among youths aged 15–34 years (1990–2021). *Diabetology & Metabolic Syndrome*, 17(1), 103.
<https://doi.org/10.1186/s13098-025-01673-0>