Diabetes-related nutrition knowledge and dietary adherence in patients with Type 2 diabetes mellitus: A mixed-methods exploratory study

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Abstract
Aim: The aim of the study is to gain insights into the relationship between diabetes-related nutrition knowledge (DRNK) and diet quality in Singapore.

Methods: Forty-two participants were recruited from a tertiary hospital. DRNK and diet quality were ascertained with the DRNK questionnaire and Alternate Healthy Eating Index 2010, respectively. Twenty-one semi-structured interviews of perceived barriers and enablers to adherence to dietary guidelines were audio recorded, transcribed and analysed.

Results: Participants had a poor mean percentage DRNK score of 39.7% (±17.7) and diet quality of 54.2% (±9.4). Pearson’s correlation tests revealed no correlation between DRNK and diet quality (r = –0.29; p = 0.065) but suggest a moderate positive correlation between DRNK and psychosocial self-efficacy (r = 0.41; p = 0.008). Thematic analysis revealed six barriers (obesogenic environment; lack of time; conflict between advice and personal values; stress from external sources; lack of personal motivation; gaps in DRNK) and four enablers (personal motivation to improve condition; fear of T2DM complications; sufficient DRNK; presence of social support) to adherence to dietary guidelines.

Conclusion: DRNK may not correlate with adherence to dietary guidelines; multiple mediating factors are identified when translating DRNK to practice.

Keywords
Diet quality, diabetes-related nutrition knowledge, barriers, enablers, type 2 diabetes mellitus

Introduction
The rising prevalence of type 2 diabetes mellitus (T2DM) is an international concern, with Asia identified as an emerging epicentre of this global epidemic.1 In Singapore, this has been forecasted to double from 7.3% in 1990 to 15% in 2050, with concomitant implications for increased healthcare expenditure.2 Despite pharmacotherapy advances, interventions targeting lifestyle changes such as medical nutrition therapy...
(MNT) and diabetes self-management education (DSME) remain the cornerstones in T2DM management. Recent studies continue to demonstrate that patients with T2DM who received and adhered to MNT and DSME had improvements in anthropometric and biomedical markers relevant to disease outcomes. One of the common dietary goals in providing MNT and DSME is to improve diabetes-related nutrition knowledge (DRNK) to facilitate positive dietary practices and augment diet quality. Having knowledge about dietary management in T2DM may strongly influence food selection and dietary behaviours. Studies have shown that provision of nutrition education can improve DRNK and dietary practices in patients with T2DM. Diabetes knowledge (including diet-related) is also highly correlated to better psychosocial self-efficacy, a strong predictor for behavioural intention and dietary behaviours in patients with T2DM. A typical MNT consult to a patient with T2DM in the clinic/ward setting is a one-on-one therapy session, lasting between 30 and 45 minutes. The frequency and content of sessions is patient dependent and guided by local dietetics department protocols and national evidence best practice guidelines. Individualising the MNT consults is part of current practice, and the dietitian will tailor their counselling to address knowledge deficits or enablers and barriers towards its application.

While imparting DRNK is fundamental in dietary interventions, the MNT is not complete without the translation of knowledge to practice (adherence to dietary guidelines). Assessment of such adherence can be measured with a diet quality index — as an indicator of adherence to dietary guidelines/evidence-based dietary recommendations. A higher diet quality has also been associated with reduced risk of all-cause mortality and 10-year predicted cardiovascular disease in patients with T2DM. Other than DRNK, there are other factors affecting the adherence to dietary guidelines. Patients with T2DM are faced with situational obstacles when it comes to selection of food on a daily basis. Previous studies have identified time constraints, cost and lack of social support to be some examples of barriers to adherence to dietary recommendations.

Despite being important components in the dietary management of T2DM, there is a dearth of research investigating factors affecting adherence to dietary guidelines in patients with T2DM. It is unclear whether better DRNK is associated with closer adherence to dietary guidelines. Our study aimed to (1) explore the correlation between DRNK and adherence to dietary guidelines, if any, and (2) describe enablers and barriers to dietary adherence in T2DM patients in Singapore.

**Methods**

We employed an embedded quantitative dominant, mixed-methods approach to this exploratory study. The quantitative and qualitative part of the study are reported in accordance to the Strengthening the Reporting of Observational studies in Epidemiology – Nutritional Epidemiology (STROBE-nut) and the COnsolidated criteria for REPorting Qualitative (COREQ) research statement, respectively. The study was approved by the National Healthcare Group Domain specific review board Reference: 2017/00941, and conducted according to the tenets of the Declaration of Helsinki. Recruited participants received information about anonymity and confidentiality, consented to take part in the study and retained a written copy of the information sheet.

Purposive sampling was employed to recruit adult T2DM patients with dietary self-management issues. These are patients referred to a dietitian for MNT as deemed necessary by their attending physician. Only participants who were literate in English were included, as the research tools/methods (surveys and interviews) were neither available nor conducted in other languages. Patients with kidney diseases, type 1 diabetes and/or who were pregnant were excluded from the study, as they were not the focus of this study. Patients with cognitive impairment were also excluded, as the diabetes-related nutrition knowledge questionnaire (DRNK-Q) is a test of knowledge.

We used a locally validated tool, the DRNK-Q, to assess the level of DRNK in our cohort. The DRNK-Q consists of four sections and 27 questions related to the topics covered in dietetic therapy and education sessions for patients with T2DM: food portion and sizes; nutrition content of food; healthier food choices and safety; and food label reading. The DRNK-Q was completed before the patients were provided with further dietary advice to prevent contamination of results.

Dietary data were derived from diet histories (7-day typical food intake is reported with a checklist of food consumed using an in-depth interview style by dietitians) collected from the participant’s respective attending dietitians who performed routine dietary assessment prior to their MNT. These diet histories were analysed with nutrient analyses software (FoodWorks 9 Professional), a local food composition database and food labels. To ensure integrity of the dietary data, we measured the ratio of individual energy intake (EI) to basal metabolic rate (BMR) using the method as described by Goldberg et al. BMR was estimated with the Harris Benedict equation, consistent with the institution’s energy estimation method for T2DM patients.

We measured degree of adherence to dietary guidelines with the Alternate Healthy Eating Index (AHEI-2010) as its components are closest to diet recommendations for individuals with T2DM in Singapore. The AHEI-2010 consists of 11 components, with score ranging 0–110. It includes six components addressing quantity and quality (vegetables; fruit; whole grains; nuts and legumes; long chain fats, percentage polyunsaturated fatty acids) and five components addressing items to be taken in moderation (sugar-sweetened beverages and fruit juice; red/processed meat; trans-fat; sodium; alcohol). Higher scores on the AHEI-2010 reflect closer adherence to dietary guidelines, indicative of better overall diet quality. We modified the scoring for sodium component by using consumption data from our national nutrition survey. We also used the adapted alcohol recommendation (<1 drink a day) as it is more culturally appropriate. Participants’ gender, age, ethnicity, weight, height, income, education, length of diabetes diagnosis, marital status and psychosocial self-efficacy (using the diabetes empowerment scale short-form) were also surveyed.
To explore the factors affecting adherence to dietary guidelines, in-depth individual interviews were conducted to allow participants to freely express their personal views. Interviews were conducted with curtains drawn if at patient's bedside, or in private rooms to ensure privacy.

C.G.C. (Senior Psychologist, PhD, second author) is a trained psychologist with expertise in management of patients with T2DM. Other than experience of delivering MNT to patients with T2DM, C.Y.H. (Senior Dietitian, first author) received training in mixed-methods research before this study. They jointly prepared two open-ended questions that aimed to encourage participants to share in-depth experiences and thoughts: (1) What are some factors that have helped you apply your nutrition knowledge to actual practice?; (2) What are some difficulties that you face when trying to apply what you have learnt about diabetes and food into your daily life? Verbal prompts were used only when participants did not spontaneously raise key issues related to the questions. C.Y.H. conducted training sessions with Z.W.W. and Y.T.C. (dietetic interns) on administering the interviews. Both interviewers are not involved with the direct care/MNT or had any prior professional contact with those enrolled. The interviews were audio recorded with a recorder model Olympus VP-10 and transcribed verbatim. Transcription was done by Y.T.C. and vetted by C.Y.H. A thematic analysis approach, vetted by C.G.C., was used to examine the content of the aforementioned interviews. Coding of the key and recurring ideas in the transcripts were described and recorded. Any coding discrepancies were resolved through a discussion with the research team until a consensus was reached. Themes and subthemes were derived from the data solely and none were identified in advance. Interviews continued until data saturation was reached, where the interviewers reported to the researcher that the same comments are being heard repeatedly (information redundancy).

All analyses were performed using SPSS version 21.0 (IBM corp). Two-sided p-values <0.05 were considered significant. Independent samples t-tests were performed to detect any differences in energy intake:basal metabolic rate (EI:BMR) ratio between two groups of participants with differing DRNK level (lower vs. higher). Independent samples t-tests and chi-square tests were used to examine any differences in sociodemographic, dietary and DRNK-Q between these two groups. Pearson’s correlation tests were performed to explore any correlation between DRNK and diet quality as well as DRNK and covariates.

Results

Out of 164 potential participants screened, 47 were recruited, and 42 and 21 were analysed for quantitative and qualitative components, respectively (Figure 1). Participants (n=42) were classified into two groups (lower vs. higher percentage DRNK) based on the median DRNK score; results presented in Tables 1 and 2. There was no significant difference (P=0.26) between degrees of under-reporting between the two groups. The mean EI:BMR ratio between groups was 1.3±0.2 and 1.1±0.3 for lower and higher DRNK groups, respectively. Statistical analyses showed no significant differences between sociodemographic background and self-efficacy between the quantitative (n=42) and qualitative (n=21) cohort (Appendix 1). We presented relevant quotes from participants to illustrate findings from the semi-structured
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interviews (range 2–10 minutes), which are referred to throughout the text in Table 3 (B1–B16; E1–9).

Participants in our cohort (n=42) had overall poor DRNK, average percentage score of 40% (±18). The mean percentage (±SD) scores for DRNK sections (1) nutrition content of food, (2) food portion and sizes, (3) healthier food choices and safety and (4) food label reading were 32% (±19), 43% (±25), 31% (±18) and 61% (±18), respectively.

**Table 1.** Analyses of participants’ demographics and characteristics by % diabetes-related nutrition knowledge (DRNK) score.

|                      | Lower DRNKa (n=21) | Higher DRNKa (n=21) | p-valueb |
|----------------------|--------------------|---------------------|----------|
| Age, years (±SD)     | 50 (16)            | 42 (12)             | 0.093    |
| BMI, kg/m² (±SD)     | 28.7 (7.7)         | 29.2 (6.4)          | 0.787    |
| Gender               |                    |                     | 0.753    |
| Male                 | 12 (57%)           | 13 (62%)            |          |
| Female               | 9 (43%)            | 8 (38%)             |          |
| Ethnicity            |                    |                     | 0.607    |
| Chinese              | 6 (29%)            | 9 (43%)             |          |
| Malay                | 8 (38%)            | 7 (33%)             |          |
| Indian               | 7 (33%)            | 5 (24%)             |          |
| Personal monthly income |               |                     | 0.003    |
| <$SGD2000            | 15 (71%)           | 5 (24%)             |          |
| SGD2000-5999         | 5 (24%)            | 16 (76%)            |          |
| ⩾SGD6000             | 1 (5%)             | 0 (0%)              |          |
| Education level      |                    |                     | 0.029    |
| Up to secondary      | 16 (76%)           | 8 (38%)             |          |
| Pre-university       | 4 (19%)            | 7 (33%)             |          |
| University/postgraduate | 1 (5%)          | 6 (29%)             |          |
| Marital Status       |                    |                     | 0.024    |
| Single               | 4 (24%)            | 11 (52%)            |          |
| Married              | 17 (81%)           | 10 (48%)            |          |
| Psychosocial self-efficacy, % score (±SD) | 75 (16) | 79 (10) | 0.253 |
| Years of diabetes diagnosis, years (±SD) | 10 (10) | 8 (8) | 0.624 |

aDRNK score range: lower 4–41; higher 44–78.
bP-values obtained by one-way independent sample t-tests for continuous variables and chi-square test for categorical variables; values reflect the mean (standard deviation) for continuous variables or n (%) for categorical variables, rounded off to the nearest percentage.

**Table 2.** Analyses of dietary characteristics by % diabetes-related nutrition knowledge (DRNK) score.

|                      | Lower DRNKa (n=21) | Higher DRNKa (n=21) | p-valueb |
|----------------------|--------------------|---------------------|----------|
| Total energy (kcal)  | 2094 (989)         | 1961 (1191)         | 0.695    |
| Total carbohydrate (g) | 267.5 (145.9)  | 239.5 (145.7)       | 0.537    |
| Total sugar (g)      | 81.9 (75.3)        | 63.4 (41.5)         | 0.333    |
| Energy contribution from carbohydrate (%) | 50.3 (10.8) | 49.5 (7.8) | 0.797 |
| Energy contribution from protein (%) | 18.3 (6.0)    | 16.8 (4.1)         | 0.346    |
| Energy contribution from fat (%) | 31.4 (8.5)   | 32.0 (6.5)         | 0.778    |
| Energy contribution from saturated fat (%) | 10.6 (3.2) | 12.0 (4.0) | 0.215 |
| Alternate Healthy Eating Index 2010 score | 57.2 (10.4) | 51.1 (7.6) | 0.039 |
| Vegetable            | 2.6 (2.3)          | 2.3 (2.2)           | 0.760    |
| Fruit                | 2.1 (2.8)          | 1.4 (1.3)           | 0.338    |
| Wholegrains          | 1.0 (1.4)          | 0.3 (0.4)           | 0.042    |
| Sugar-sweetened beverage and fruit juice | 3.0 (4.3) | 2.2 (3.9) | 0.490 |
| Nuts and legumes     | 5.9 (6.6)          | 5.7 (4.6)           | 0.911    |
| Red or processed meat | 8.3 (2.2)   | 7.1 (3.9)           | 0.213    |
| EPA+DHA              | 3.5 (3.7)          | 1.3 (2.3)           | 0.025    |
| PUFA                 | 5.6 (2.9)          | 4.9 (2.3)           | 0.405    |
| Sodium               | 6.8 (4.3)          | 6.2 (3.9)           | 0.605    |
| Alcohol              | 9.8 (0.9)          | 10.0 (0.0)          | 0.747    |

aDRNK score range: lower 4–41; higher 44–78.
bP-values obtained by one-way independent sample t-tests for continuous variables; values reflect the mean (standard deviation); complete adherence to AHEI-2010 (trans-fat) in both groups.
### Table 3. Sample quotes from qualitative interviews by theme.

| Quote # | Main theme | Sub-theme | Participant’s quote |
|---------|------------|-----------|---------------------|
| **Barriers to dietary adherence** | **Obesogenic environment** | | |
| B1 | Limited availability of healthy food choices | | “I think the environment factor also plays a role. If you are in an environment whereby the food choices is very limited, sometimes there is (laugh) so little that you can, you know, do for your diet.” (#24, Chinese woman, 32 years) |
| B2 | Easy access to food high in fat and sugar | | “Nowadays so much fast food going on, all those eatery outside” (#09, Malay man, 70 years) |
| B3 | Work environment requiring food handling | | “Because of my nature of my job, I have to teach people to cook. Six days I got aunty coming in for curry every day. You can’t expect me eat any other thing of course I want to join them in the curry. So this are some of the days and these are . . . . not talking about just six curry in one day. It could be braised duck, braised meat, curry rendang and thing lar” (#29, Chinese man, 58 years) |
| B4 | Social media featuring unhealthy food | | “Ah I feel that now the social media like Instagram especially and you know you have people who having diabetes and conditions like this, they will stumble upon Instagram that shows you know, cakes and foods, you know those food porn kind of thing, so they tend to go astray (laugh)” (#33, Malay woman, 47 years) |
| **Lack of personal motivation** | | | |
| B5 | Unmotivated to change current habits | | “This really a lot difficult. We already eat so many years of white rice you suddenly got [diabetes] you need to change, a lot of thing you cannot eat” (#32, Chinese woman, 33 years) |
| B6 | Being in pre-contemplative stage of change | | “Is when I feel that I’m not uh, I’m not, I don’t have the diabetic, I’m a normal person. So as a normal person, I don’t need to see, think so much. Everything is okay to me” (#17, Chinese woman, 58 years) |
| **Lack of time** | | | |
| B7 | Busy work schedules | | “It means, uh any work factors, uh any uh timeframe that maybe didn’t didn’t fit your time to eat regularly, especially the medication and the type of food that have been prescribed on you” (#14, Malay man, 56 years) |
| **Conflict between advice and personal values** | B8 | Perception of time needed to prepare healthier food vs. time willing to use to prepare healthier food | “I would think that you need to make a lot of uh, advance preparation lar, if let’s say we do what to apply what we have learnt. Uh, ya, you need to head to the supermarket et cetera in advance [to get the so call] healthy food et cetera and you bring it yourself along” (#24, Chinese woman, 32 years) |
| B9 | Perception of cost of healthier food vs. willingness/ability to pay for food | | “Because normally they say, ah this one is diabetic friendly, then you choose the product which is cheaper, and maybe taste nicer, but may not be diabetic friendly” (#27, Malay man, 60 years) |
| B10 | Perception of healthier food vs. personal food preferences | | “But if I eat something like bread, you know, wholemeal bread. At the beginning yes, I can eat you know, but in a run ar, wah, I cannot take it already, you know. I don’t feel fulfil” (#30, Malay man 45 years) |
| B11 | Perception that foods appropriate for one’s culture are unhealthy | | “Because like especially uh tsk, for us Malay ar you know one, all the dishes ar all like, tsk, can be very oily this sort of things” (#30, Malay man 45 years) |
| **Stress from external sources** | B12 | Pressure from family to control condition | “Probably is uh feel very stressful, very . . . . u know, stressful and very irritated. When getting . . . . angry sometime when you cannot have what do you want lar, so your family control” (#04, Indian man, 55 years) |
| B13 | Stress from unsupportive friends | | “Friends also important. When you go out, you see them eat you cannot eat, this is also one of the difficulty” (#32, Chinese woman, 33 years) |
| B14 | Financial stress from cost of diabetes | | “Outside, whenever you eat outside, the, that’s not very much like range of healthy food right. And then furthermore ju- to- just to control the diabetes, the medicine and the items for example the test strips, the glucose test strip . . . . . . is very very expensive” (#18, Malay woman, 32 years) |
| **Gaps in diabetes-related nutrition knowledge** | B15 | Lack of knowledge | “But those who have no knowledge, they don’t know you can substitute this for that, which is more healthier” (#27, Malay man, 60 years) |
| B16 | Unable to retain knowledge | | “And I think the main factor is for for the health authority to just keep on educating people like us who are maybe not uh savvy, incompetent or that kind of stuff” (#14, Malay man, 56 years) |
| **Enablers to dietary adherence** | **Presence of social support** | | |
| E1 | Support from healthcare professionals | | “Uh, in the hospital, the., the professional people lar are helping me lar” (#06, Indian woman, 41 years) |
On average, participants failed (<50%) three out of four components of the DRNK questionnaire. Only 31% of the participants managed to pass the DRNK questionnaire (total score =50%). It is worth mentioning that participants had a wide range of DRNK from 4% to 78% and a median of 44%.

Independent sample t-tests revealed that participants in the higher DRNK group scored significantly higher in all four sections of the DRNK-Q as compared with those in the lower DRNK group (p<0.05 for all). There were significantly more participants in the lower DRNK group that were married, and belonged to the lower personal monthly income and education groups (p<0.05 for all).

The average total daily EI, percentage of energy contribution from carbohydrate, protein and fat was 2028±1070 kcal, 50±9%, 17±5% and 32±7%, respectively. The mean overall diet quality score in our cohort (n=42), as ascertained by the AHEI-2010, was 54.2±9.4. The median diet quality score was 54.2, with poorest intake in the following components: whole grains, fruits, vegetables, long chain n-3 polyunsaturated fatty acids, excessive sugar-sweetened beverages and fruit juice.

With reference to Table 2, participants belonging to the higher DRNK group tended to have lesser total energy, carbohydrate and sugar intake from their diets on average, though the differences did not reach a statistical significance. On contrary, participants in the higher DRNK group averaged a significantly lower diet quality as ascertained by the AHEI-2010 (p=0.039). The subcomponents that were significantly lower were wholegrains (p=0.042) and EPA+DHA (p=0.025). Pearson’s tests did not suggest any correlation between DRNK and overall diet quality (r=−0.29; p=0.065) or other covariates. However, a moderate positive correlation between DRNK and psychosocial self-efficacy was observed (r=0.41; p=0.008).

From the interviews, participants often felt that their environment offered limited healthier food choices (B1) and easy access to those high in fat and sugar (B2), detering them from selecting foods that were deemed healthier. This included work environments that required handling of food such as in a kitchen (B3). They also see social media platforms featuring ‘unhealthy’ food as another environmental (media) barrier towards adherence to dietary guidelines (B4).

The lack of motivation to change current habits (B5) or being in a pre-contemplative stage of change (B6) often surfaced as barriers towards adherence to dietary guidelines. Participants described that busy work schedules made regular meals difficult and discourage them from making healthier food choices (B7).

The differences in participants’ perception of time (B8) and financial cost (B9) involved to include healthier food in their diet were brought up as barriers. Personal opinions and recommended food suitable for individuals with T2DM also compete with their usual food preference (B10) and culture (B11). Participants reported that pressure from family members to maintain a ‘diabetic diet’ was often perceived as stressful (B12). They also felt pressure from friends that were unsupportive towards their decision to choose healthier food options when dining out (B13). Financial costs associated with other aspects of diabetes self-care were also identified as a

### Table 3. (Continued)

| Quote # | Main theme | Sub-theme | Participant’s quote |
|---------|------------|-----------|---------------------|
| **E2** | Support from friends/peers | “Having friends who have uh same kind of uh, you know, uh having diabetes as you, same as you. So, you can actually help uh encourage each other, you know uhm is better than being alone, I think having someone to correlate to actually really helps me a lot on this lar” (#24, Malay woman, 32 years) |
| **E3** | Support from religious movement/beliefs | “God can help” (#10, Chinese man, 80 years) |
| **E4** | Support from family members | “Outside my whole family very sad about my toe. And my daughter explained to me: Mum, you can’t take mum, you’ve to take care, everything must stop” (#13, Indian woman, 56 years) |

### Presence of personal motivation to improve condition

| Quote # | Main theme | Sub-theme | Participant’s quote |
|---------|------------|-----------|---------------------|
| **E5** | Individual responsibility towards managing condition | “I think in terms of my understanding, uh, we need to really take active concern of our health. After all at the end of the day, we are the one who are facing the music, if we don’t really take good care of it lar” (#14, Malay man, 56 years) |
| **E6** | Recognition of importance of diet control | “To get correct food ar, in order not to increase our diabetes lar” (#04, Indian man, 55 years) |

### Fear of diabetes complications

| Quote # | Main theme | Sub-theme | Participant’s quote |
|---------|------------|-----------|---------------------|
| **E7** | Fear of suffering | “Oh, because I’ve been through with all the symptoms. My sugar is pretty high before, like this time, this time was the highest ah 29.9, need to go toilet more often., then pain in your privates, alright, then the foreskin is tighten, then you have constipation, then you have like tiredness, you get really tired” (#05, Chinese man, 43 years) |
| **E8** | Fear of death | “I have a friend that have already passed away because of uhm from diabetes leads to kidney and affect all the other organs, the body. So, he was quite young around my age, thirty two!” (#18, Malay woman, 32 years) |

### Sufficient diabetes-related nutrition knowledge

| Quote # | Main theme | Sub-theme | Participant’s quote |
|---------|------------|-----------|---------------------|
| **E9** | Availability of resources that can help patients improve their diabetes-related nutrition knowledge | “So I think these knowledge, information and this kind of thing will help to educate patient like me to to have a better life lar. To practice more healthy diet and so on... we need to educate this every on ongoing” (#14, Malay man, 55 years) |
source of added stress that resulted in deprioritising adher- ence to dietary guidelines (B1). Participants reported that the lack of DRNK (B15) and the inability to retain the taught knowledge (B16) as other reasons for poor adherence to dietary guidelines. There was a general tendency to feel that such knowledge should be imparted through repeated education sessions.

In terms of enablers to healthy eating, participants perceived that support from healthcare professionals (E1), family members (E2), friends/peers (E3) and religious movement/beliefs (E4) as facilitators towards better adherence to dietary guidelines. Participants claimed that the presence of personal motivation, through feelings of individual responsibility towards managing T2DM (E5) and acknowledgement of the importance of diet control (E6) were enablers towards adherence to dietary recommendations. Participants also described the fear of diabetes-related complications leading to sufferings such as uncomfortable hyperglycaemia symptoms (E7) or death (E8) as enablers. They recognised having sufficient DRNK as essential in helping them make healthier food choices, highlighting the necessity of having continuous access to a DRNK source to sustain positive dietary changes (E9).

Discussion

This is the first study to report on DRNK levels and factors affecting adherence to dietary guidelines in Singapore. Other than an overall poor DRNK and diet quality, we found a moderate positive correlation between DRNK and psychosocial self-efficacy and identified factors affecting DRNK and adherence to dietary guidelines.

Our cohort had a lower mean DRNK as compared with a recent similar study that found mean DRNK to be 59.2±16.4%. This could be due to a higher proportion of lower socio-economic class participants in our study (48% vs. 31%), as socio-economic status has an impact on nutrition knowledge. During education, pictorial and teach back methods can be implemented routinely for those with a lower level of educational attainment. The moderate positive correlation between DRNK and self-efficacy in our cohort is similar to another study in India (r 0.317; p<0.001). As evidence is scarce, a prospective investigation is warranted to examine if improving DRNK is associated with better self-efficacy.

We observed fair diet quality scores in our cohort similar to other studies reporting scores ranging from 40.2 to 58.8, with poor intake of wholegrains, dairy, fruits and vegetables. In Singapore, the promotion of wholegrains, fruits and vegetables is ubiquitous among public diabetes-related health messages, guidelines and education. However, our findings suggest that these health promotional messages may not necessarily be translated into ‘process knowledge’ in patients with T2DM. Previously studies have shown a weak positive relationship between nutrition knowledge and diet quality in the general population. The lack of correlation between DRNK and diet quality in our cohort of patients with T2DM suggests the influence of mediating factors between them.

Our qualitative data provided insights to possible mediators between DRNK and diet quality, lending support to our conceptual framework describing local factors affecting adherence to dietary guidelines in patients with T2DM (Figure 2).
Cumulatively, the perceptions of barriers towards adherence to dietary guidelines were mostly extrinsic. There was an overarching sentiment that an obesogenic environment was the key reason. It is well known that the built and workplace environment play a substantial role in dietary practices and prevention of obesity.\(^{38,39}\) In addition, we found digital social media to be a part of these environments promoting unhealthier food choices and hindering adherence to healthier food choices.

Participants also identified having a busy work schedule as a barrier towards adherence to dietary recommendations, which resulted in prioritising satiety over recommended ‘acceptable food’.\(^{40-41}\) Some participants reported resentment towards their family and friends’ ‘over-controlling’ behaviour on their diet, isolating them by disallowing participation in consumption of certain communal food at social events. While social support can foster positivity towards diabetes self-care activities, an opposite effect can arise from such negative social interactions.\(^{42}\)

The burden of diabetes-related expenses such as medication was also reported to compete with perceived financial costs associated with healthy eating. A local study revealed that the diabetes-related medical cost in Singapore (USD1575.6 per annum per patient) was indeed higher than other Asian countries.\(^{43}\)

While patients can be motivated through a sense of responsibility towards T2DM and recognition of importance of diet in diabetes self-care, the lack of it was identified as a barrier to improving eating habits.\(^{44}\)

In coherence with having poor DRNK on average, some participants described trouble processing or recalling information provided to them. Inadequate understanding of the diet–disease link has been a long-standing barrier towards adherence to dietary guidelines.\(^{16}\) The differences in perspectives between dietary advice and what participants were able to accept or change may also give rise to negative connotations towards diet adherence.\(^{45}\) Therefore, individualised DRNK education sessions play a vital role to synthesise old and new knowledge to help improve compliance to dietary recommendations and MNT.\(^{45-46}\) Time spent with healthcare professionals may have a far-reaching effect on diet adherence. Relationship and trust between healthcare providers and patients have been associated with improved adherence to diabetes self-care practices.\(^{47,48}\)

The present exploratory study has several strengths. The use of a locally validated questionnaire ensured cultural appropriateness and accuracy when assessing DRNK. The purposive sampling method allowed us to recruit from our population of interest, gaining new insights to the issue surrounding a common group of acute care patients. However, our results are not without limitations. We recognise that the dietary data collected can be affected by acute events and change in appetite leading to the participant’s acute care admission. However, this was taken into consideration as patients referred for poor oral intake were excluded in our study. The small sample size collected from a single institution also limits the generalisability of our results. We consolidated themes from our results and created the Barriers and Enablers to Healthy Eating (BE-2-HE) checklist available in English, Mandarin, Malay and Tamil (Appendix 2). However, further study is suggested to validate it among non-English speaking individuals with T2DM. Other factors that may influence diet such as prior dietary intervention, presence of T2DM complications, and prior incidences of hypoglycaemia were not assessed in this study. We also suggest that future research has a prospective design with a larger sample size to investigate the causal relationship between DRNK and diet quality and if reduction of barriers and/or increment of enablers to dietary guidelines recommendations are directly associated with higher diet quality.

Conclusion

We identified factors, including DRNK, mediating adherence to dietary guidelines. Though DRNK is fundamental to individuals with T2DM, dietary counselling for patients with T2DM goes beyond a one-off nutrition education session. It is important to enforce follow-up dietitian sessions to explore facilitators and barriers towards translating DRNK into practice. Consequently, there is a role for dietitians to empower patients with T2DM beyond increasing DRNK. The BE-2-HE checklist could facilitate dietary counselling by helping patients with T2DM self-identify factors affecting adherence to dietary guidelines before seeing their healthcare practitioners. However, further detailed research is suggested to validate and ascertain its usefulness.

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Author Declaration

I, C.Y.H., hereby certify that the manuscript that I am submitting on behalf of all authors is entirely original, where otherwise indicated. I am aware of the journal’s regulations concerning plagiarism, including those regulations concerning disciplinary actions that may result from plagiarism. Any use of the works of any other author, in any form, is properly acknowledged at their point of use.

Authors’ contributions

C.Y.H. and M.F.C. conceived of the presented idea, developed the theory and study design. C.Y.H., X.M., Y.T.C., Z.W.W. carried out the project, while K.B. and M.F.C. supervised. C.Y.H, C.G.C., K.M., K.F.T., K.B., M.F.C. and S.L.L contributed to the interpretation of the results. C.Y.H. took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript.

Availability of data

Upon reader’s request and approval from the NHG domain specific ethics review board.

Ethical approval

The study was approved by the Domain specific review board (NHG DSRB Reference: 2017/0094).

Informed Consent

Informed consent was provided by all participants.
Declaration of conflicting interests
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