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Patients' self-perceived awareness of drug–drug and drug–food interactions: A cross-sectional study in southern Saudi Arabia

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Abstract: **Background**: Patients' self-perceived awareness of drug–drug interactions (DDIs) and drug–food interactions (DFIs) is important for medication safety, yet interaction-related counseling remains limited. **Objectives**: To assess patients' self-perceived awareness of DDIs/DFIs and identify sociodemographic correlates of insufficient awareness in tertiary outpatient pharmacies of southern Saudi Arabia. **Methods**: A cross-sectional survey was conducted at two tertiary hospitals over six months. Adults ≥18 years attending outpatient pharmacies were recruited via consecutive sampling. A structured, self-administered questionnaire, refined by expert review, collected data on demographics, awareness, attitudes and behaviors. Insufficient self-perceived awareness was defined a priori as a moderate, weak, or very weak rating on a five-point Likert scale. Internal consistency was assessed via Cronbach's alpha. Associations were examined using χ^2 with Cramer's V and multivariable logistic regression estimated adjusted odds ratios (aORs) with 95% confidence intervals (CIs). **Results**: Of 401 patients approached, 353 consented; after excluding 12 records aged <18 years, 341 participants (52.8% female) formed the analytic sample. Overall, 22.3% (95% CI 18.2–27.0) reported insufficient awareness. Counseling on DDIs (7.6%) and DFIs (6.2%) was uncommon; DDIs (54.0%) and DFIs (51.3%) were the most frequent unclear topics. A two-item attitudinal subscale showed acceptable internal consistency ($\alpha = 0.75$). After adjustment, only older age remained an independent predictor (aOR ≥51 vs 18–40 = 8.33, 95% CI 3.10–22.40), while education was not (aOR 1.11, 0.57–2.16). **Conclusion**: Insufficient self-perceived awareness of DDIs/DFIs was substantial. Older age, rather than education, was the only independent correlate, suggesting the unadjusted education association may be age-confounded. Targeted, age-sensitive pharmacist-led counseling may improve medication safety. Findings are exploratory given reliance on a self-perceived measure.

Keywords: Attitudes; Drug interactions; Food–drug interactions; Health knowledge; Patient education as topic; Practice; Cross-sectional studies; Saudi Arabia

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INTRODUCTION

Medication safety is a global public-health priority and unrecognized drug interactions remain a preventable yet substantial source of avoidable patient harm. Polypharmacy has grown steadily as populations age and multimorbidity increases, expanding opportunities for drug–drug interactions (DDIs) and drug–food interactions (DFIs) across care settings (Rodrigues and Oliveira, 2016; Zazzara *et al*., 2021). Such interactions can alter pharmacokinetics or pharmacodynamics, reducing effectiveness or precipitating adverse drug events (ADEs)—such as gastrointestinal and intracranial bleeding from anticoagulant or antiplatelet combinations, hypoglycemia from interacting antidiabetic agents, QT-interval prolongation and torsades de pointes, serotonin syndrome, statin-associated rhabdomyolysis and acute kidney injury— that contribute to prolonged hospitalizations and higher costs (Zazzara *et al*., 2021; Magro *et al*., 2012). Among DFIs, grapefruit constituents inhibit intestinal cytochrome P450 3A4 (CYP3A4) and transporters, leading to clinically important exposure changes for many drugs (Limandri, 2020; de Boer *et al*., 2015). However, clinically relevant interactions extend beyond grapefruit, including vitamin K–rich foods reducing warfarin efficacy (Holbrook *et al*., 2012), dairy products decreasing tetracycline and fluoroquinolone absorption (Schmidt and Dalhoff, 2002; Sharma *et al*., 2014), high-protein meals lowering levodopa bioavailability (Cereda *et al*., 2010) and tyramine-containing foods causing hypertensive crises with monoamine oxidase inhibitors (Yamada and Yasuhara, 2004). Overall, DFIs remain an important and often under-recognized source of variability in drug response (Genser, 2008).

Globally, DDIs are estimated to contribute to approximately 20–30% of ADEs, with clinically significant interactions accounting for a substantial proportion of preventable medication-related hospitalizations, particularly among patients with polypharmacy and chronic conditions (Magro *et al*., 2012). Although DFIs are less frequently reported in surveillance systems, they can meaningfully alter drug exposure, efficacy, or safety and are recognized contributors to avoidable morbidity when unrecognized or poorly managed (Tannenbaum and Sheehan, 2014). These risks are amplified in settings with high medication use and limited patient counseling, underscoring the

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importance of patient awareness as a component of medication safety.

DDIs are associated with important clinical outcomes, including ADEs, treatment failure and medication-related hospitalizations. In a large prospective hospital study, adverse drug reactions accounted for approximately 6.5% of hospital admissions, with many considered preventable and related to medication interactions and polypharmacy (Pirmohamed *et al*., 2004). More broadly, epidemiological analyses suggest that DDIs contribute to approximately 20–30% of ADEs (Magro *et al*., 2012; Tannenbaum and Sheehan, 2014). In addition, regional factors such as increasing medication use, chronic disease burden and self-medication practices may further increase interaction risk. In Saudi Arabia, concurrent use of prescription medicines with herbal products and supplements has also been documented and represents an additional potential source of clinically significant interactions (Albassam *et al*., 2021).

Despite extensive attention to prescriber- and system-level prevention, the patient perspective remains a critical link in the medication-safety chain. Patients' perceived understanding of interaction risks, where they seek information and how they act when an interaction is suspected can directly influence outcomes. Systematic evaluations show that dispensing encounters and counseling can improve patients' medication knowledge, yet interaction-specific content is often incomplete or inconsistently emphasized (Zaidi *et al*., 2021; Alorfi *et al*., 2023). Healthcare professionals themselves may have knowledge gaps regarding DFIs, reinforcing the need for structured, reliable patient education at the pharmacy interface (Alorfi *et al*., 2023).

Regional data from Saudi Arabia point to similar challenges. Community-based surveys in Jeddah found poor to intermediate public self-reported awareness of DFIs and professional surveys report variable DDI knowledge among pharmacists, indicating opportunities for targeted education and decision-support at points of care (Noor and Assiri, 2022; Noor *et al*., 2017). More broadly, medication-safety reviews in Saudi settings highlight opportunities within systems for standardized counseling, improved patient–provider communication, and the wider use of validated resources to reduce preventable harm from interactions (Alghamdi, 2025; Aljadhey *et al*., 2014).

While several studies in Saudi Arabia have examined awareness of DDIs and DFIs among the general public, most have focused on community populations rather than patients actively receiving prescriptions in clinical settings (Zaidi *et al*., 2021). Other studies have evaluated interaction knowledge among healthcare professionals rather than patients (Alorfi *et al*., 2023; Alrabiah *et al*., 2019). Consequently, limited evidence exists regarding how patients in routine outpatient care understand potential drug interactions, what counseling information they recall and how they respond when interactions are suspected. The present study addresses this gap by examining multiple patient-centered domains—including information received, unclear counseling points, behavioral responses to suspected interactions and attitudes toward learning—among patients attending tertiary hospital outpatient pharmacies in southern Saudi Arabia.

Against this background, a cross-sectional survey was conducted in two tertiary hospitals in southern Saudi Arabia to (1) estimate the proportion of patients with insufficient self-perceived awareness of their current medications with respect to DDIs and DFIs; (2) characterize what information patients report receiving, what remains unclear to them and how they respond when they suspect an interaction; (3) examine the internal consistency of attitudinal items using Cronbach's alpha; and (4) evaluate sociodemographic correlates of insufficient awareness using both unadjusted and confounder-adjusted analyses. The findings aim to inform literacy-sensitive, pharmacist-led counseling strategies and patient education practices in outpatient pharmacy settings, contributing to improved communication about medication interactions in routine clinical care.

MATERIALS AND METHODS

Study design and setting

A quantitative, cross-sectional survey was conducted between January and June 2023 at two tertiary care hospitals in southern Saudi Arabia. The survey assessed patients' self-perceived awareness of their current medications—particularly DDIs and DFIs—their information sources and their behaviors when interactions were suspected. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting checklist, which was used to guide transparent reporting of the observational study design and results (Vandenbroucke *et al*., 2007). The overall study workflow is summarized in a research flowchart (Fig. 1), and the completed STROBE checklist is provided as a supplementary file. The protocol was approved by the Institutional Ethics Committee (Approval No. ECC202215 and KKU-97-2026-14). Participation was voluntary; all respondents provided written informed consent and data were collected anonymously and stored securely in accordance with institutional policy.

Inclusion and exclusion criteria

Eligible participants were adults aged ≥18 years attending the outpatient pharmacies of the two participating tertiary hospitals for either new or refill prescriptions during the six-month study period.

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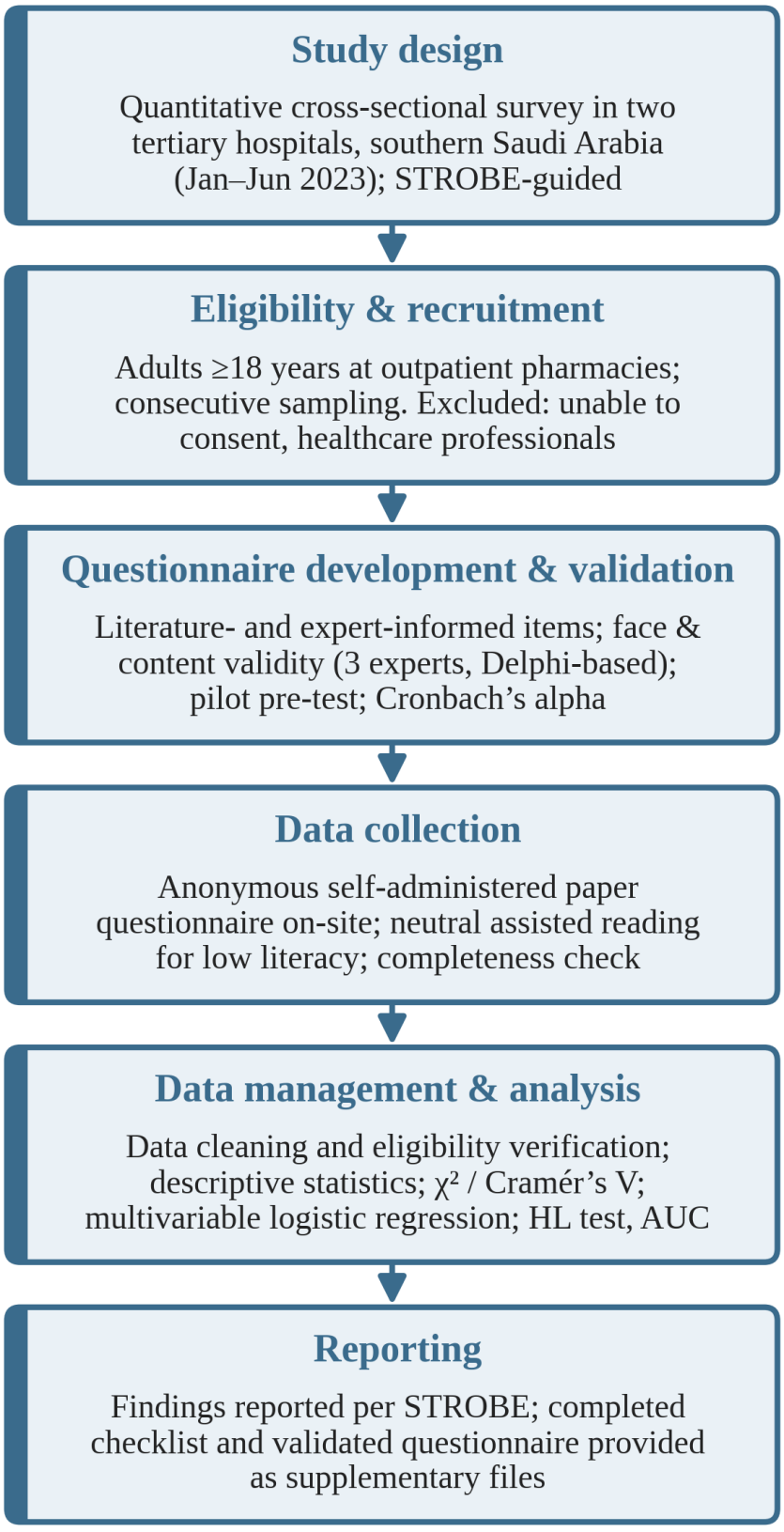


Fig. 1: Research (study methodology) flow chart summarizing the overall study workflow, from design and participant eligibility through questionnaire development and validation, data collection, data management and statistical analysis, and STROBE-based reporting. This diagram complements the STROBE participant-flow diagram shown in figure 2.

Patients who were unable to provide informed consent and healthcare professionals were excluded. Healthcare professionals were specifically excluded to avoid inflating awareness estimates due to formal training and professional exposure to medication-related information, and to ensure that the findings reflected the experiences of the general, non-professional patient population.

Sampling and recruitment procedures

Consecutive sampling was employed during outpatient pharmacy operating hours on scheduled clinic days throughout the study period. Eligible patients were approached sequentially as they presented to the outpatient pharmacy, with recruitment conducted across multiple days and time periods to capture routine patient flow, consistent with prior outpatient survey methodologies (Zaidi *et al*., 2021). During the study period, approximately 401 eligible patients were approached; of these, 353 consented and completed the survey, while the remaining patients declined participation, yielding a response rate of approximately 88%.

Questionnaire development and validation

A structured, self-administered questionnaire was developed to assess: (1) self-perceived awareness of DDIs and DFIs; (2) attitudes toward and interest in learning about medication interactions; (3) information received and unclear counseling points; and (4) self-reported behaviors when an interaction was suspected. The questionnaire also included sections on patient demographics, sources of medication information, and reported experiences with suspected interactions. Self-perceived awareness was assessed using a five-point Likert scale ranging from "very weak" to "excellent," which was later categorized into sufficient and insufficient awareness for descriptive analysis. A targeted literature review and local clinical experience informed item generation. The literature search was conducted between May and July 2022 using PubMed and Google Scholar. Combinations of keywords including "patient awareness," "drug–drug interaction," "drug–food interaction," "medication knowledge," and "patient counseling" were used. Articles published in English up to 2022 were screened for relevance. Studies examining patient awareness, counseling practices, or behavioral responses to suspected medication interactions were reviewed to identify commonly reported domains and item formats. The search was intended to guide domain selection and item wording and did not constitute a systematic review. Draft questionnaire items were subsequently reviewed by three independent experts in clinical pharmacy and medication safety to assess clarity, relevance and face validity, following recommended Delphi-based expert-consensus principles for instrument development (Nasa *et al*., 2021; Shinners *et al*., 2021). This expert review was conducted to refine wording and ensure alignment with the study objectives. Instrument validation followed a structured, multi-step process. Face validity was confirmed through expert review of item clarity, phrasing and comprehensibility, while content validity was established by the same panel of three clinical-pharmacy and medication-safety experts, who independently judged the relevance and representativeness of each item against the study objectives; items were retained, reworded, or removed by consensus. The instrument was then pilot-tested with a small convenience sample of ten outpatients to confirm comprehensibility, cultural appropriateness and average completion time; pretest responses were used solely to finalize wording and were not included in the analytic sample. A limited pretest of this size is consistent with methodological guidance indicating that approximately 10–30 respondents are generally sufficient to detect comprehension and formatting problems during questionnaire pre-testing (Nasa *et al*., 2021). Reliability (internal consistency) was subsequently quantified using Cronbach's alpha, which reached the conventional acceptability threshold for the a priori two-item attitudinal subscale ($\alpha = 0.75$). Formal construct validity (e.g., exploratory factor analysis) and test–retest reliability were not undertaken and this is acknowledged as a study limitation.

Internal consistency of the four attitudinal items measured on a four-point Likert scale (perceived importance of DDI/DFI knowledge, self-rated consideration of DDIs/DFIs, worry about possible DDIs and interest in learning more) was assessed using Cronbach's alpha. Because the items were not designed as a single unidimensional scale, the coefficient was computed both for the full four-item set and for an a priori conceptual two-item subscale (perceived importance and interest in learning) reflecting attitudinal engagement with interaction-related knowledge. Other psychometric evaluations, including exploratory factor analysis, construct validity testing, and test–retest reliability, were not conducted.

Data collection

Trained pharmacy interns and research assistants approached eligible patients in outpatient pharmacy waiting areas. After written consent was obtained, participants completed the paper questionnaire on-site, independently whenever possible to minimize response bias. For individuals with limited literacy, trained research assistants read the questions aloud and recorded responses verbatim without providing interpretation or guidance, thereby maintaining neutrality. Completed forms were checked for completeness before secure entry into the dataset. Because the objective was to characterize patients' self-perceived awareness rather than to detect clinically confirmed interactions, drug–drug and drug–food interactions were not screened, graded, or verified

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using interaction-checking software (e.g., Lexicomp, Micromedex, or Stockley's Drug Interactions); every reported or suspected interaction therefore reflects patient perception, not pharmacist or software adjudication. Several procedural safeguards were used to limit bias: the questionnaire was anonymous and self-administered to reduce social-desirability bias; assistance for participants with limited literacy was restricted to neutral, verbatim reading without interpretation to reduce interviewer bias; consecutive sampling across multiple days and shifts was used to reduce selection bias; and forms were screened for completeness to limit information bias. Residual recall and social-desirability bias cannot be excluded and are addressed in the Limitations.

Variables and operational definitions

The primary outcome of this study was insufficient self-perceived awareness of current medications, defined a priori as participants rating their overall awareness as moderate, weak, or very weak on the five-point Likert scale, while those rating their awareness as excellent or good were considered to have sufficient awareness. This construct reflects patients' subjective perception of their understanding of potential DDIs and DFIs rather than an objective assessment of pharmacological knowledge. The term "insufficient awareness" was adopted deliberately—rather than "poor knowledge"—to signal that the outcome is a self-perceived (subjective) construct, captured by a single global self-rating item and operationalized a priori using a fixed cut-point on the five-point Likert scale (moderate, weak, or very weak = insufficient; good or excellent = sufficient). This wording and threshold were chosen so that the variable, its aim and its measurement are explicitly aligned: the study estimates the proportion of patients who themselves appraise their understanding of DDIs/DFIs as inadequate, not the proportion with externally verified knowledge deficits.

The secondary outcomes included four domains: (1) the specific types of information received about medications—such as dose, indication, side effects, DDIs and DFIs; (2) unclear counseling points identified by participants, including DDIs, DFIs and side-effect discussions; (3) actions taken when an interaction was suspected, such as stopping the medication, consulting a doctor or pharmacist, or checking information on the internet; and (4) participants' attitudes and interest toward learning more about DDIs and DFIs.

Sample size justification

The required sample size was estimated using the standard formula for single-proportion estimation in cross-sectional surveys (Pourhoseingholi *et al*., 2013). Specifically, the minimum sample size was derived from the formula $n = Z^2P(1-P)/d^2$, where $Z = 1.96$ corresponds to a 95% confidence level, $P = 0.25$ is the assumed prevalence of insufficient self-perceived awareness based on prior regional data and $d = 0.05$ is the absolute margin of error. Substituting these values gives $n = (1.96^2 \times 0.25 \times 0.75)/0.05^2 \approx 288$ participants. Assuming a prevalence of insufficient self-perceived awareness of approximately 25% based on prior regional data, a 95% confidence level ($Z = 1.96$) and a margin of error of ±5%, the minimum required sample size was calculated to be approximately 288 participants. To ensure adequate precision and allow exploratory subgroup comparisons, a sample of approximately 350 participants was targeted.

Statistical analysis

Data were entered in Microsoft Excel and analyzed using R (version 4.3.1) (R Core Team, 2023). In line with the prespecified eligibility criterion of age ≥18 years, twelve records with reported age below 18 years were excluded from the analysis, yielding a final analytic sample of 341 participants. Descriptive statistics summarized categorical variables as counts and percentages and proportions are reported with 95% Wilson confidence intervals (CIs) for the primary outcome. Internal consistency of attitudinal items was assessed using Cronbach's alpha (a value of ≥0.70 was considered acceptable). Associations between sociodemographic factors and insufficient awareness were first examined using the χ^2 test of independence with Cramér's V as a measure of effect size; Fisher's exact test was applied for small expected counts. A multivariable logistic regression model was then fitted with insufficient self-perceived awareness as the dependent variable and the following prespecified covariates as independent variables: age group (18–40 [reference], 41–50, ≥51 years), sex, lower educational attainment (no formal/high-school vs college or above), presence of any chronic disease, hospital type, insurance status and residence (urban vs rural). Adjusted odds ratios (aORs) with 95% CIs were reported. Model fit was evaluated using the Hosmer–Lemeshow test and discrimination was assessed using the area under the receiver operating characteristic curve (AUC). Statistical significance was set at $p < 0.05$ (two-sided). Missing data were minimal (<5%), restricted to selected demographic items and were addressed by complete-case analysis without imputation. The analytic strategy was chosen to match the data structure and the study aim. Because the primary outcome was binary (sufficient vs insufficient self-perceived awareness), multivariable logistic regression was the appropriate method for estimating the independent association of each predictor while adjusting for the others. Covariates were specified a priori on clinical and epidemiological grounds rather than by data-driven stepwise selection, to limit overfitting and preserve the interpretability of the adjusted odds ratios. Cramér's V was reported alongside the χ^2 tests to convey the strength (and not only the statistical significance) of bivariate associations, and the adequacy of the final model was verified through calibration (Hosmer–Lemeshow test) and discrimination (AUC).

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RESULTS

Participant characteristics

Of 401 eligible patients approached, 353 consented and completed the survey (response rate ≈88%). Following application of the prespecified eligibility criterion of age ≥18 years, 12 records were excluded, yielding a final analytic sample of 341 participants (Fig. 2). As shown in table 1, 52.8% were female and 47.2% male. The age distribution was 34.6% aged 18–30 years, 23.5% aged 31–40 years, 30.5% aged 41–50 years, 8.5% aged 51–70 years and 2.9% older than 70 years. Regarding education, 53.4% held a college degree, 29.3% had a high school diploma or less, 10.3% were uneducated and unable to read and 7.0% had a master's degree or other certificate. Employment status varied, with 31.4% government employees, 29.6% unemployed, 18.2% private-sector employees, 5.9% self-employed/free business and 15.0% reporting other statuses.

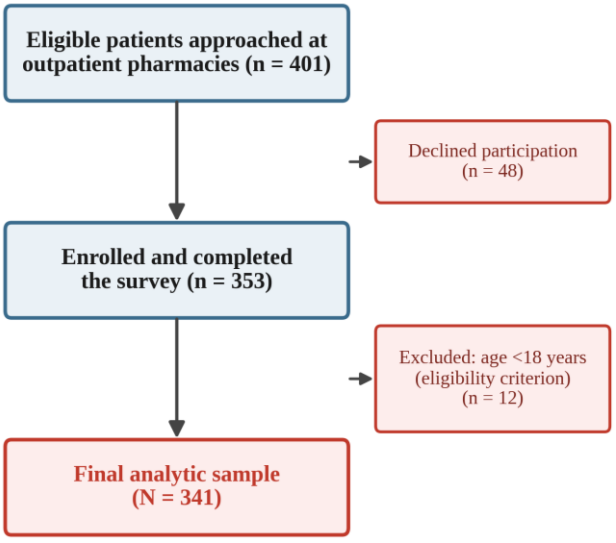


Fig. 2: STROBE participant flow diagram. Of 401 eligible patients approached at the outpatient pharmacies of two tertiary hospitals in southern Saudi Arabia, 48 declined participation and 353 consented and completed the survey. After applying the prespecified eligibility criterion of age ≥18 years, 12 records with reported age below 18 years were excluded, yielding the final analytic sample of N = 341. Statistical analyses comprised descriptive summaries, χ^2 tests with Cramér's V, multivariable logistic regression with model-fit assessment (Hosmer–Lemeshow test, AUC), and Cronbach's alpha for the attitudinal subscale.

More than half (54.8%) attended government hospitals, while 45.2% attended private hospitals. Most participants resided in urban areas (86.8%). A large proportion (70.1%) reported having no medical insurance, while 21.4% had private insurance and 4.1% government insurance. Common chronic conditions included glandular disorders (22.6%), hypertension (19.6%), digestive disorders (8.8%), lipid disorder (8.8%), lung and respiratory diseases (7.6%) and cardiovascular diseases (7.6%); 39.6% reported no chronic condition. Twenty-nine percent of participants reported multimorbidity (≥2 chronic conditions).

Overall self-perceived awareness of medications

As illustrated in figure 3, 22.3% (95% Wilson CI 18.2–27.0) of participants were classified as having insufficient self-perceived awareness of their current medications, defined as rating awareness as moderate, weak, or very weak on the five-point scale. The remaining 77.7% were categorized as having sufficient awareness (excellent or good).

Medication information received and unclear counseling topics

Figure 4A presents the types of medication information participants recalled receiving from healthcare providers. Most respondents reported receiving counseling about dose (88.6%) and how to use (68.0%). Fewer reported receiving information about mechanism of action (30.5%), when to stop (23.5%), side effects (21.4%), or cost (10.3%). Interaction-specific counseling was notably limited: only 7.6% reported being informed about DDIs and 6.2% about DFIs.

As shown in figure 4B, when asked which aspects of their medications remained unclear, DDIs (54.0%) and DFIs (51.3%) were the most frequently cited topics. Side effects were reported as unclear by 35.8% of participants, and cost by 15.0%. These findings indicate that interaction-related information was both infrequently delivered and frequently not well understood.

Experiences and actions related to suspected interactions

Figure 5A shows participants' reported experiences with potential interactions. Around 14% (14.4%) of participants reported experiencing a possible DDI or DFI, 31.1% were unsure whether they had experienced one, and 54.5% reported no prior experience. When participants suspected an interaction (Fig. 5B), the most frequently reported actions were notifying a doctor (61.0%) and stopping the medication (58.9%); fewer reported consulting a pharmacist (31.7%). Additional behaviors included asking a friend or relative (7.0%), checking information online (10.3%), changing the dose (4.1%) and changing the frequency (2.3%). Multiple responses were permitted.

Sources of interaction information and attitudes toward learning

Figure 6A illustrates reported best sources of interaction information.

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Table 1: Demographic and clinical characteristics of study participants (N = 341).

Variable	n (N = 341)	Percentage (%)
Sex		
Male	161	47.21
Female	180	52.79
Age (years)		
18–30	118	34.60
31–40	80	23.46
41–50	104	30.50
51–70	29	8.50
>70	10	2.93
Education level		
Uneducated/unable to read	35	10.26
High school diploma or less	100	29.33
College degree	182	53.37
Master's degree or other certificate	24	7.04
Employment status		
Unemployed	101	29.62
Government employee	107	31.38
Private-sector employee	62	18.18
Self-employed/free business	20	5.87
Other	51	14.96
Hospital type		
Government hospital	187	54.84
Private hospital	154	45.16
Health status		
No chronic disease	135	39.59
Hypertension	67	19.65
Cardiovascular disease	26	7.62
Lung and respiratory disease	26	7.62
Lipid disorder	30	8.80
Arthritis	18	5.28
Cancer	12	3.52
Ulcers	13	3.81
Central nervous system disorder	21	6.16
Digestive disorder	30	8.80
Blood disease	11	3.23
Bone and joint disease	19	5.57
Visual disorder	19	5.57
Glandular disorder	77	22.58
Other	21	6.16
Residential status		
Urban	296	86.80
Rural	45	13.20
Medical insurance		
Government	14	4.11
Private	73	21.41
No insurance	239	70.09
Other	15	4.40

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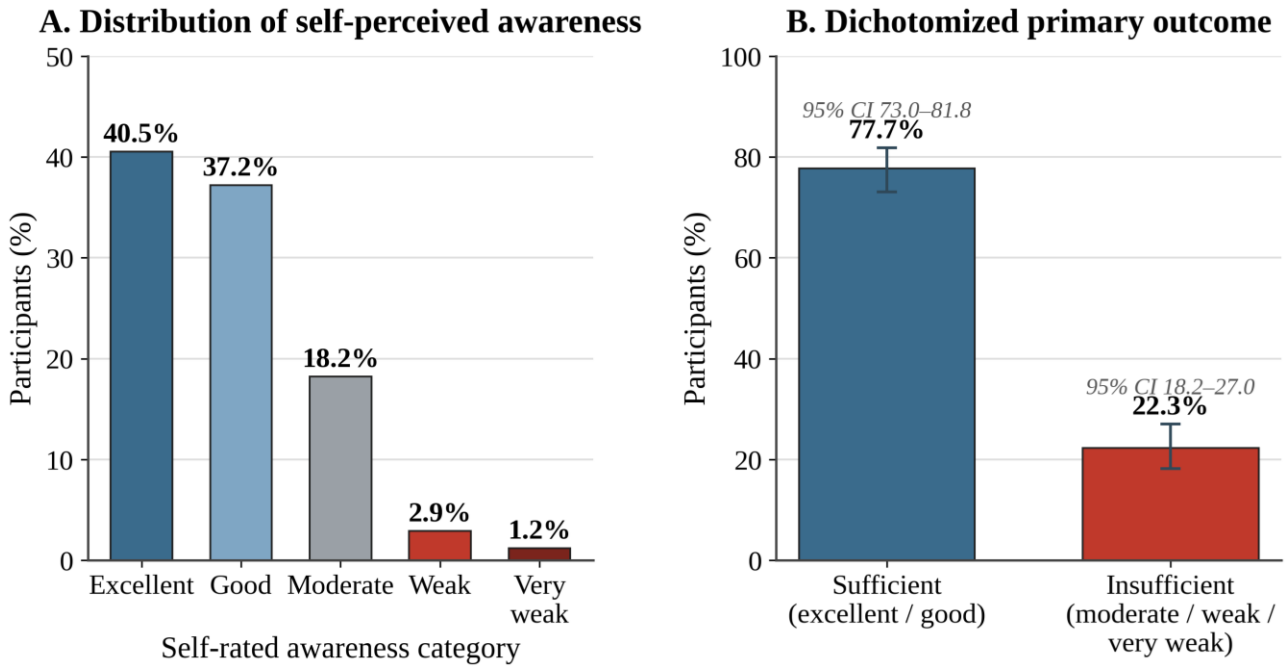


Fig. 3: Self-perceived awareness of current medications (N = 341). (A) Distribution of participants across the five-point Likert scale of self-rated awareness (excellent, good, moderate, weak, very weak); (B) Dichotomized primary outcome showing the proportion of participants classified as having sufficient or insufficient self-perceived awareness; insufficient awareness was defined a priori as rating overall awareness as moderate, weak, or very weak. Error bars in panel B represent 95% Wilson confidence intervals.

The most frequently reported reliable sources were the doctor (62.8%), the pharmacist (51.3%) and the internet (49.6%); the patient information leaflet was selected by 28.4% and friends or relatives by 9.1%. Multiple responses were allowed. Attitudinal responses are shown in Figures 6B and 6C. Regarding the perceived importance of DDI/DFI knowledge (Fig. 6B), 59.2% strongly agreed and 30.8% agreed that such knowledge is important, while 7.9% disagreed and 2.1% strongly disagreed. In terms of interest in learning more (Fig. 6C), 44.9% strongly agreed and 44.3% agreed that they were interested in learning more about DDIs and DFIs; 7.0% disagreed and 3.8% strongly disagreed. Collectively, these findings demonstrate high perceived importance and strong interest in DDI/DFI knowledge despite limited recall of interaction-specific counseling.

Internal consistency of attitudinal items

Internal consistency of the four attitudinal items as a single scale was poor (Cronbach's $\alpha = 0.47$), reflecting the multidimensional nature of the questions (perceived importance, self-rated consideration, worry and interest). The conceptually homogeneous two-item subscale (perceived importance and interest in learning), reflecting attitudinal engagement with DDI/DFI knowledge, demonstrated acceptable internal consistency (Cronbach's $\alpha = 0.75$; Pearson $r = 0.60$), supporting use of these items as a brief indicator of patient interest in interaction-related education in similar populations.

Sociodemographic correlates of insufficient awareness

In univariate analysis, lower educational attainment was significantly associated with insufficient self-perceived awareness ($\chi^2(3) = 28.57$, $p < 0.001$; Cramér's $V = 0.29$), with the proportion of insufficient awareness ranging from 4.2% among those holding a master's degree to 54.3% among uneducated participants. Older age was also strongly associated with insufficient awareness, with 65.5% of participants aged 51–70 years and 70.0% of those older than 70 years reporting insufficient awareness, compared with 13.6% in those aged 18–30 years (Fig. 7). However, in the multivariable logistic regression model (Table 2 and Fig. 8), only older age (≥51 years) remained an independent predictor of insufficient self-perceived awareness (aOR = 8.33, 95% CI 3.10–22.40, $p < 0.001$), while lower education (aOR = 1.11, 95% CI 0.57–2.16, $p = 0.761$), sex, hospital type, insurance status, residence and chronic disease burden were not. The model demonstrated acceptable goodness-of-fit (Hosmer–Lemeshow $\chi^2 = 13.29$, $p = 0.10$) and acceptable discrimination (AUC = 0.69). These findings indicate that the unadjusted association between lower education and insufficient awareness was largely confounded by age and that age is the dominant independent correlate of self-perceived awareness in this sample.

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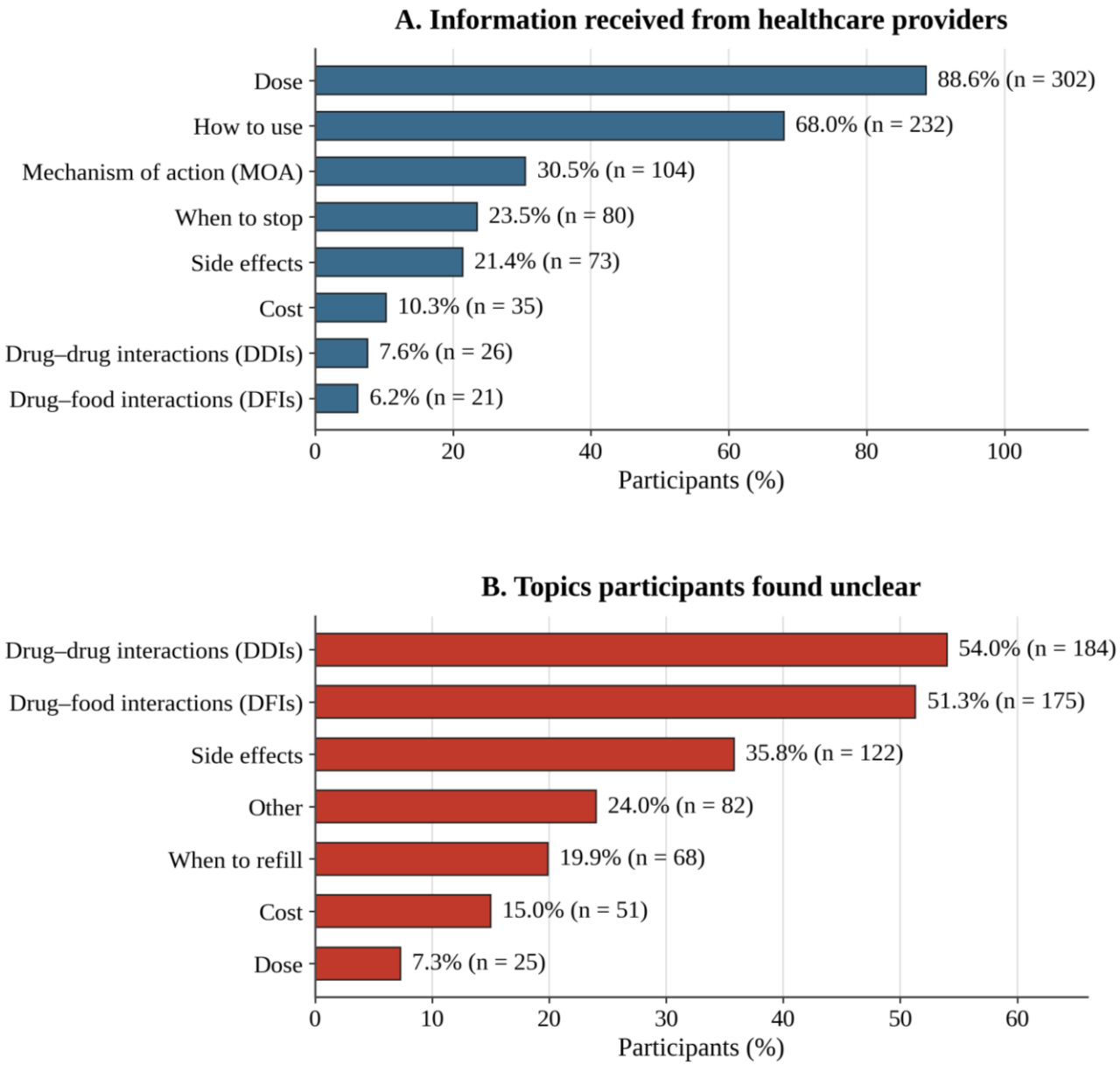


Fig. 4: Medication information received and unclear counseling points (N = 341). (A) Proportion of participants reporting information received from healthcare providers regarding their medications, including dose, how to use, mechanism of action, when to stop, side effects, cost, DDIs and DFIs. (B) Areas of medication counseling identified as unclear by participants. Multiple responses were allowed where applicable.

DISCUSSION

Prevalence and sociodemographic correlates of insufficient awareness

In this two-hospital cross-sectional study from southern Saudi Arabia (N = 341), nearly one in four patients reported insufficient self-perceived awareness of their current medications. Although lower educational attainment showed a statistically significant univariate association with insufficient awareness, this association did not persist after adjustment for age, sex, hospital type, insurance status, residence and chronic disease burden. Older age (≥51 years) was the only independent predictor and showed a large adjusted effect. This pattern is consistent with the confounding of the education effect by age in this population, in which older patients are more likely to have lower formal educational attainment and to report lower medication awareness. Similar patterns of age-driven disparities in medication understanding have been described in older patient populations elsewhere (Rodrigues and Oliveira, 2016; Yıldırım and Kilinc, 2017).

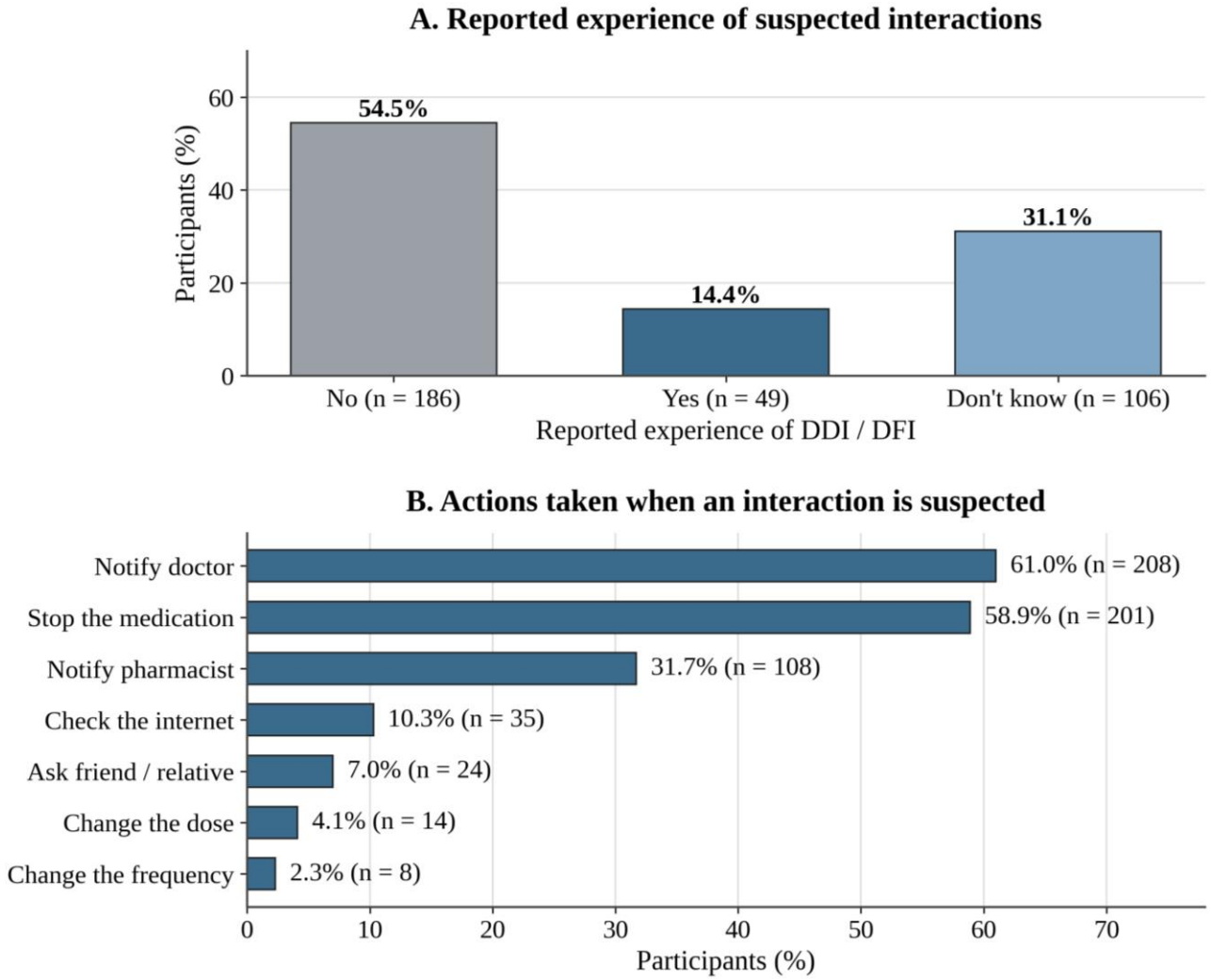


Fig. 5: Reported experiences and actions related to suspected drug interactions (N = 341). (A) Proportion of participants reporting prior experience of DDIs/DFIs, uncertainty regarding such experience, or no experience; (B) Reported actions taken when an interaction was suspected. Multiple responses were allowed in panel B.

Interaction-related counseling, unclear topics and behavioral responses

Counseling was heavily weighted toward dose and how to use, whereas counseling regarding DDIs and DFIs was rarely reported. Previous research has similarly documented gaps in interaction-related counseling in routine dispensing encounters (Rodrigues and Oliveira, 2016; Zaidi *et al*., 2021). When interactions were suspected, patients most frequently stopped medication or contacted their physician, while consultation with pharmacists was less common. Similar patterns of limited pharmacist engagement in interaction counseling have been described in prior Saudi studies (Alorfi *et al*., 2023; Alrabiah *et al*., 2019). Despite identifying physicians and pharmacists as trusted sources of information, participants frequently relied on internet-based sources. Comparable reliance on non-professional information sources has also been reported in international medication-awareness studies (Zazzara *et al*., 2021; Bin Yousef *et al*., 2022).

Interpretation, biological plausibility and the role of age

The observed pattern aligns with global evidence that DDIs are a leading cause of preventable adverse drug reactions and hospitalizations, while DFIs remain under-recognized yet clinically important (Zazzara *et al*., 2021; Magro *et al*., 2012; de Boer *et al*., 2015; Tannenbaum and Sheehan, 2014; Sandson *et al*., 2005). The independent age effect observed here is biologically plausible: older patients more often experience polypharmacy, cognitive load related to complex regimens, sensory or cognitive decline that limits health-information processing and lower historical exposure to interaction-related counseling, all of which can reduce subjective confidence in their medication knowledge (Rodrigues and Oliveira, 2016; Yildirim and Kılınc, 2017; Kuzuya, 2023).

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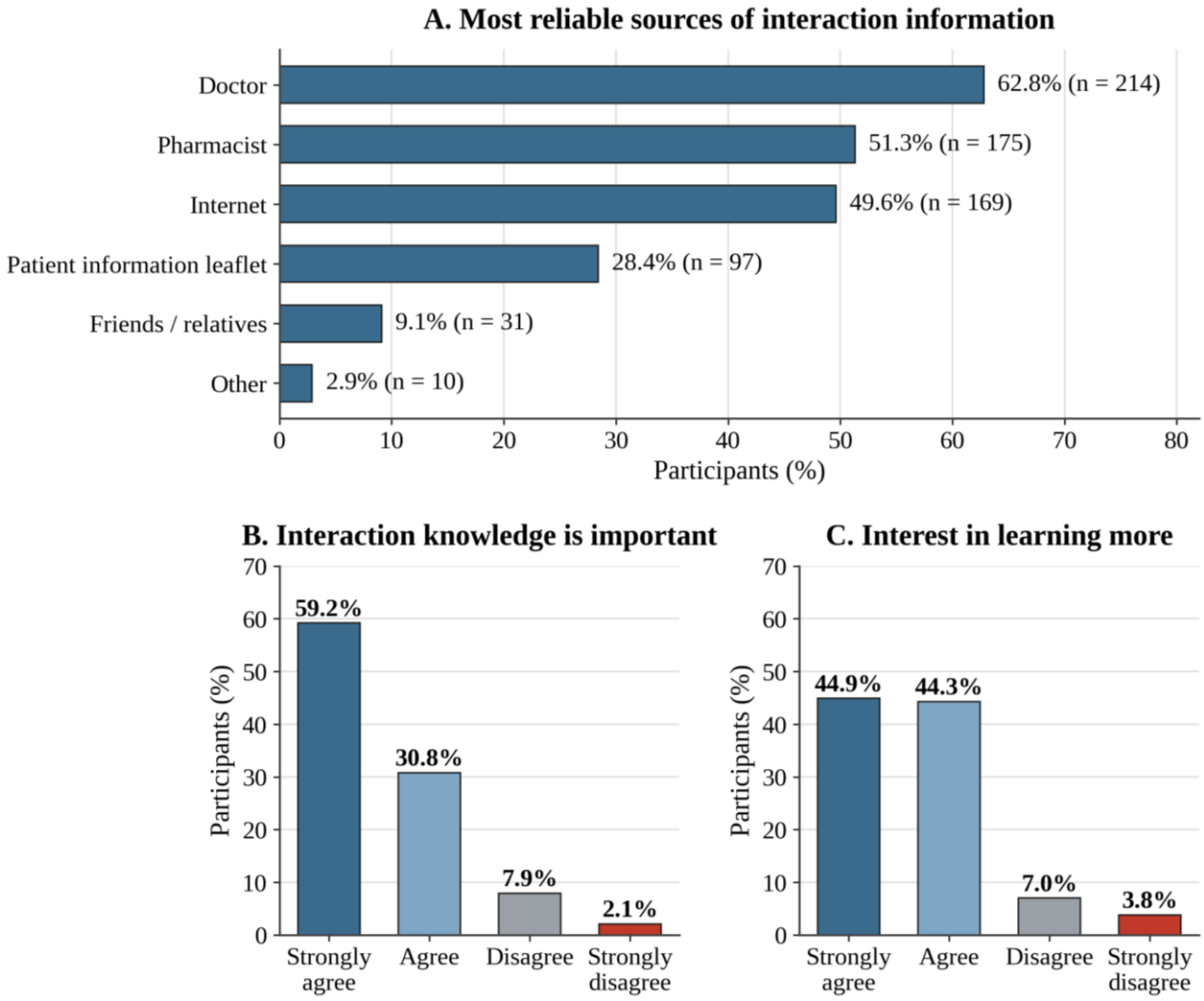


Fig. 6: Sources of interaction information and attitudes toward learning (N = 341). (A) Sources participants reported using to identify potential DDIs/DFIs. Multiple responses were allowed; (B) Participants' perceived importance of knowledge regarding DDIs and DFIs; (C) Participants' interest in learning more about DDIs and DFIs.

Consistent with this, a recent cross-sectional study of older outpatients in Saudi Arabia found that potential drug–drug interactions were common and were strongly associated with polypharmacy and chronic disease burden, both of which increase with age (Alshehri, 2026). The present results emphasize the importance of age-tailored counseling and reinforce calls to design patient education interventions explicitly for older adults, rather than assuming that lower educational attainment is the principal driver. Structured written materials in the patient's native language have been shown to significantly enhance medication knowledge and retention, supporting the integration of written counseling into routine pharmacy practice (Rameshkumar *et al*., 2022). The acceptable internal consistency of the two-item attitudinal subscale (importance and interest; $\alpha = 0.75$) further suggests that brief, patient-engagement indicators could be incorporated into routine pharmacy counseling assessments, although broader psychometric evaluation across different populations would be needed before such items are used as a stand-alone scale.

Clinical and health-system implications

From a health-system perspective, the findings highlight the need for improved patient counseling regarding DDIs and DFIs during routine outpatient care. Interaction-related counseling should be integrated into standard medication education provided by healthcare professionals at the point of prescribing and dispensing. Evidence from medication safety research indicates that structured counseling during dispensing encounters can improve patients' understanding of their medications and potential interaction risks (Rodrigues and Oliveira, 2016). In the present study, physicians were the most frequently consulted professionals when participants suspected a potential interaction.

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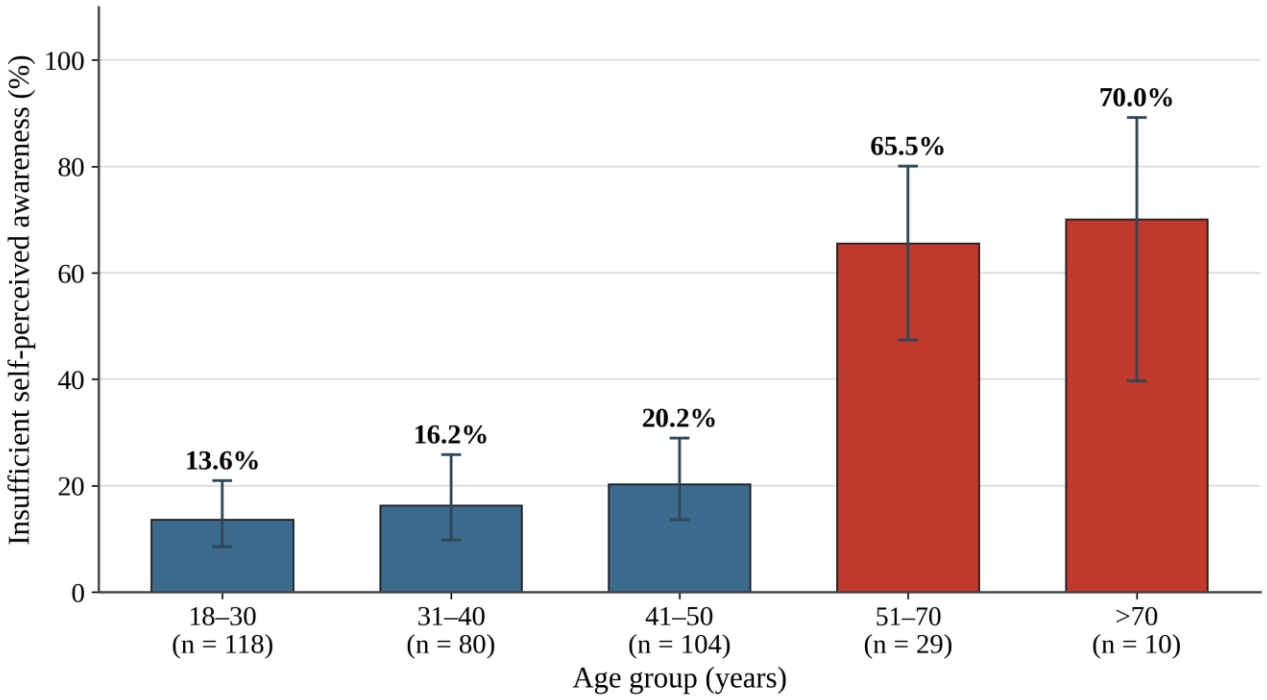


Fig. 7: Insufficient self-perceived medication awareness by age group (N = 341). The proportion of participants reporting insufficient self-perceived awareness rose markedly from 13.6% in the 18–30 age group to 65.5% in the 51–70 age group and 70.0% in those older than 70 years. Error bars represent 95% Wilson confidence intervals.

Table 2: Crude and adjusted odds ratios for insufficient self-perceived medication awareness from univariate and multivariable logistic regression (N = 341).

Predictor	Crude OR (95% CI)	Adjusted OR (95% CI)	p-value
Age 41–50 vs 18–40	1.47 (0.79–2.74)	1.20 (0.60–2.41)	0.610
Age ≥51 vs 18–40	11.66 (5.38–25.26)	8.33 (3.10–22.40)	<0.001
Female vs male	1.14 (0.68–1.90)	1.23 (0.69–2.21)	0.486
Lower education (none/high-school) vs college+	2.63 (1.56–4.43)	1.11 (0.57–2.16)	0.761
Has any chronic disease	2.34 (1.32–4.14)	1.25 (0.60–2.59)	0.546
Private vs government hospital	0.56 (0.33–0.95)	1.08 (0.52–2.22)	0.836
Has insurance (govt/private)	0.47 (0.24–0.93)	0.67 (0.30–1.50)	0.330
Rural vs urban	2.74 (1.41–5.30)	1.79 (0.84–3.81)	0.131

aOR: adjusted odds ratio; CI: confidence interval. Reference categories: age 18–40 years, male sex, college degree or higher, no chronic disease, government hospital, no medical insurance, urban residence. The Hosmer–Lemeshow goodness-of-fit test indicated acceptable model calibration (χ^2 = 13.29, p = 0.10), and the area under the receiver operating characteristic curve was 0.69.

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This pattern is consistent with previous surveys reporting that patients often rely on physicians as their primary source of medication-related information (Zaidi *et al*., 2021). Pharmacists, however, remain highly accessible medication experts and can play an important role in reinforcing interaction-related counseling and patient education. Studies assessing pharmacists' knowledge and involvement in drug interaction management in Saudi Arabia have also emphasized the need to strengthen pharmacists' participation in medication counseling (Alorfi *et al*., 2023). In addition to professional counseling, structured patient education tools such as written medication information and clear communication strategies can improve patient understanding and medication safety (Zazzara *et al*., 2021). Strengthening patient–provider communication and promoting reliable educational resources may help reduce reliance on informal internet sources and improve safe medication use.

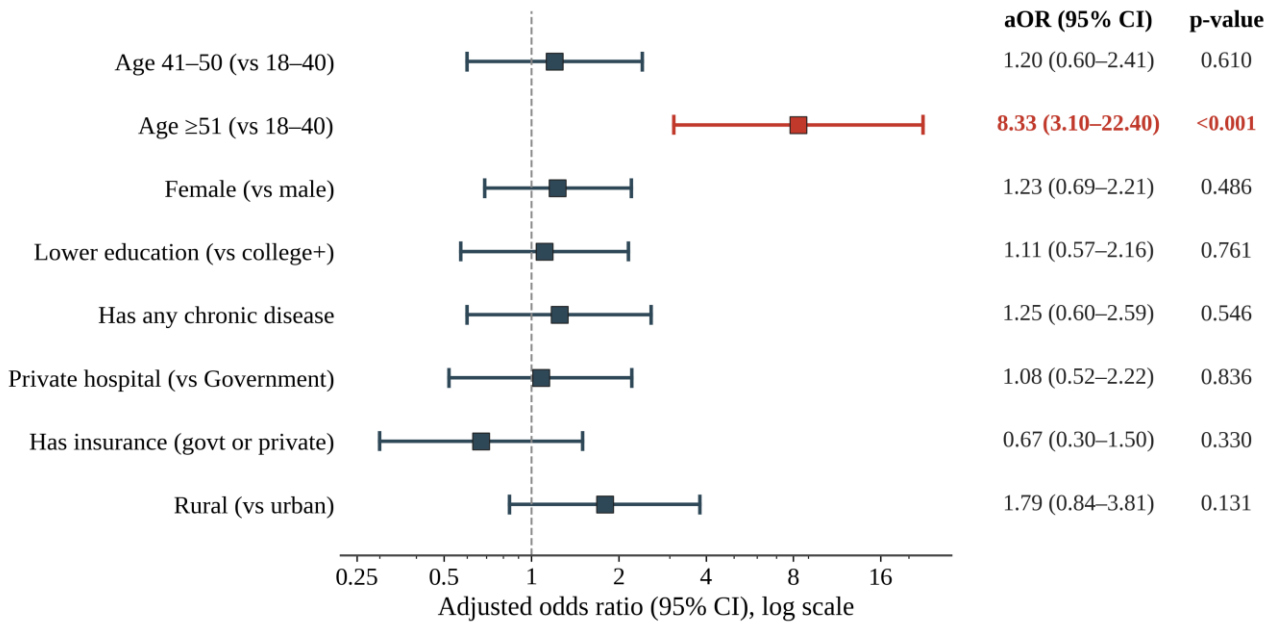


Fig. 8. Forest plot of adjusted odds ratios from the multivariable logistic regression model for insufficient self-perceived medication awareness (N = 341). Squares represent the point estimate of the adjusted odds ratio (aOR) and horizontal bars represent the 95% confidence intervals. The vertical dashed line indicates the null value (aOR = 1). The only statistically significant independent correlate after adjustment was age ≥51 years (highlighted in red).

CONCLUSION

In conclusion, patients in this study demonstrated substantial uncertainty regarding DDIs and DFIs, infrequent exposure to interaction-specific counseling and frequent reliance on the internet as an information source alongside healthcare professionals. Although lower educational attainment showed a strong unadjusted association with insufficient self-perceived awareness, this association did not persist after multivariable adjustment and older age (≥51 years) emerged as the only independent correlate. Addressing these gaps will require structured, age-sensitive, pharmacist-delivered counseling supported by clear written materials and electronic decision-support tools. Embedding such interventions into routine outpatient pharmacy practice may represent a feasible approach to improving medication-interaction awareness and promoting safer medication use. Because the findings are based on self-perceived rather than objectively assessed awareness and on a partially validated questionnaire, they should be interpreted as exploratory and descriptive.

Limitations and future recommendations

This study has several strengths, including the use of a structured, self-administered questionnaire, consecutive sampling across two tertiary hospitals, and multivariable logistic regression to assess independent correlates of self-perceived awareness while adjusting for key sociodemographic confounders. Nevertheless, several important limitations should be considered. First, the cross-sectional design precludes causal inference, and reliance on self-reported data introduces potential recall and social-desirability biases. Accordingly, all self-reported estimates—including the prevalence of insufficient awareness and the reported counseling, experience and behavioral items—should be interpreted with caution, because self-perception may diverge from objectively measured knowledge and actual behavior and respondents may over- or under-report depending on confidence and perceived expectations. Second, awareness was measured using a subjective, self-perceived scale rather than an objective knowledge assessment; therefore, the findings reflect perceived understanding (which may be influenced by confidence, education, or response tendencies) rather than verified pharmacological knowledge and the primary outcome should be regarded as an indicator of self-confidence in medication knowledge rather than a validated indicator of actual interaction literacy. Third, although the questionnaire underwent expert review for content clarity and relevance, the four attitudinal items as a single composite did not achieve acceptable internal consistency ($\alpha = 0.47$) and only an a priori two-item subscale (importance and interest) reached the conventional threshold ($\alpha = 0.75$); therefore, the questionnaire as a whole should not be regarded as a fully validated psychometric tool. Construct validity testing, exploratory factor analysis, and test–retest reliability were not conducted, and the present findings should accordingly be

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considered exploratory descriptive evidence pending broader psychometric evaluation. Fourth, reported interaction experiences were based on patient perception rather than clinical confirmation, and the accuracy of the online information sources consulted by participants was not evaluated. Fifth, recruitment was limited to outpatient pharmacy settings within a single region, which may have excluded individuals with lower healthcare engagement or irregular access to medical services, and may have limited the generalizability of the findings. Sixth, although a multivariable logistic regression was performed and identified older age as an independent correlate, the number of older participants (51–70 years: n = 29; >70 years: n = 10) was modest, leading to wide confidence intervals around the age-related odds ratio; this estimate should therefore be interpreted with appropriate caution and confirmed in larger samples. These limitations should be carefully considered when interpreting the study findings, and the results should be regarded as an exploratory description of patient-reported awareness and behaviors rather than definitive evidence of medication safety performance.

Future recommendations: Future research should evaluate pharmacist-led and age-adapted counseling strategies designed to improve patient awareness of DDIs and DFIs in outpatient settings. Studies incorporating objective knowledge assessments, formally validated psychometric instruments (with reliability and construct-validity testing) and multicenter sampling could better characterize independent predictors of interaction awareness and patient behavior, as variations in medication knowledge across patient populations have been reported in prior surveys (Zaidi *et al*., 2021). Evaluating the impact of structured counseling tools and reliable educational resources on patient understanding may also help reduce reliance on informal information sources and improve medication safety (Zazzara *et al*., 2021).

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Authors' contributions
Abdullah A. Assiri designed the study, developed the questionnaire, supervised data collection, conducted the analysis and wrote and revised the manuscript. The author approved the final manuscript and is accountable for all aspects of the work. Contributors involved only in data collection are acknowledged separately. AI-based tools assisted with language editing and figure formatting; the author retained full responsibility for study design, analysis, interpretation and final manuscript content.

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Data availability statement
The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request. The study questionnaire and the completed STROBE reporting checklist are provided as supplementary files for the journal office and reviewers.

Ethical approval
The study protocol was approved by the Institutional Ethics Committee (Approval No. ECC202215 and KKU-97-2026-14). All participants provided written informed consent prior to enrolment. This study was performed in adherence with the STROBE guidelines. See supplementary file for the STROBE checklist.

Conflict of interest
The author declares no competing interests.

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