

## Assessing Antibiotics Misconducting Impacts on Environmental Sustainability

**Mohammed A Alsanad<sup>1\*</sup>, Ahmed IH Ismail<sup>2,3</sup>, Abdulrahman M Almadini<sup>4</sup>**

<sup>1</sup>*Department of Environment and Agricultural Natural Resources, College of Agricultural and Food Sciences, King Faisal University, P.O. Box 400, Al Ahsa 31982, Kingdom of Saudi Arabia, KFU, KSA*

<sup>2</sup>*Department of Agribusiness and Consumer Sciences, College of Agricultural and Food Sciences, KFU, KSA*

<sup>3</sup>*Department of Rural Community & Agricultural Extension, College of Agriculture, Ain Shams Univ., Egypt*

<sup>4</sup>*Retired Prof. of Soil Fertility and Environmental Management, Agric. Environment and Natural Resources Department, College of Agric. and Food Sciences, KFU, KSA*

**\*Corresponding Author:** Mohammed A Alsanad, Department of Environment and Agricultural Natural Resources, College of Agricultural and Food Sciences, King Faisal University, P.O. Box 400, Al Ahsa 31982, Kingdom of Saudi Arabia, KFU, KSA.

**Received:** April 19, 2022; **Published:** April 30, 2022

DOI:

### Abstract

The current study aims to assess the impacts of improper use and conduct of antibiotics on environmental sustainability as well as human health and the community perceptions in KSA towards such issues adopting the Eastern province as a case study. The study involved a sample of 325 individuals that were randomly selected and surveyed from the community of the province. They questionnaires were explicitly designed on basis of direct contact and interviews. Obtained data were analyzed using SPSS software program following proper statistical formats. The findings of the study revealed that most of the respondents were unprivileged in their perceptions to proper use and conduct of antibiotics, knowledge about use guidelines, and the negative impact of antibiotic misuses and misconducts on environment, with a high correlation value ( $r^2=0.872$ ). Thus, there are sincere needs to a strategy to improve their concepts towards such aspects. The proposed strategy ought to involve extensive extension programs and setting and implementing legislations to regulate handling processes of antibiotics in the country. Success of these legislations however requires full collaboration between all related sectors. It is therefore conceived that these findings are valuable to sustain the environment in the KSA in line with the national 2030 strategy.

**Keywords:** Antibiotics; Misuse; Misconduct; Human Health; Environmental Protection

### Introduction

Antibiotics are vital medicinal substances generally used in treating patients infected with bacteria. Van Boeckel et al. (2015) indicated that their global consumption estimates vary from  $10 \times 10^5$  to  $20 \times 10^5$  tons per year. However, public misuse of antibiotics has emerged as a challenging issue to the concerned authorities. Numerous social surveys showed that various worldwide communities lack adequate knowledge concerning the proper use of antibiotics and their misuse consequences on environment (Al-Yasserri et al., 2019; Nisabwe et al., 2020; Shahpawee et al., 2020; Marzan et al., 2021).

Likewise, several studies conducted over different regions of KSA indicated that majority of surveyed people used antibiotics without medical prescriptions, and they could get them directly from a pharmacy without visiting a physician (Al Akhali et al., 2013; Emeka

et al., 2014; El Zowalaty et al., 2016). These studies also disclosed that these surveyed people usually make their own decision to use antibiotics and/or rely on others' experiences (e.g., friends and/or relatives). Such behavior was rationalized by the easy access to antibiotics and the ineffective implementation of legislations regulating antibiotic purchasing and utilization. In an explorative descriptive meeting-based study conducted in Orissa, India, Sahoo et al. (2010) concluded that poor execution of legislations leads to antibiotics misuse in both levels of patients and professionals, which together with inappropriate disposal arrangements of antibiotics may cause major contaminating damage to the environment and its components including air, water, and lands.

In addition, antibiotics are commonly used in agricultural activities evidently for health safety and feeding of animals of husbandry farms and as plant promoting growth substances (Al-Mustafa and Al-Ghamdi, 2002; Manyi-Loh et al., 2018; Alsanad, 2019; Koirala et al., 2021). They are also used in aquaculture farming (Manage, 2018; Gazal et al., 2020). The overused and/or misused residuals of antibiotics will cause negative effects on environment and hence on human health (Li et al., 2017; Alsanad, 2019; Ben et al., 2019; Polianciuc et al., 2020; Serwecińska, 2020).

Thus, the present investigation aims to assess the impacts of improper use and conduct of antibiotics on the environmental sustainability and the community perceptions in the KSA towards such issues assuming the Eastern Province as a case study. It comprises survey of the awareness of participants towards antibiotics proper utilization and conducting processes (i.e., how to deal with them and with their leftovers) and the levels of their perception towards the regulations of antibiotics use and the risk of their random misuse and misconduct on the environmental sustainability and human health.

## Materials and methods

### *Research methodology and data collection*

The study was based on a descriptive meeting survey to evaluate the community awareness towards the negative impacts of antibiotics misuse on environment in the Eastern Province of the KSA. The province is one of the largest Saudi provinces in area and population being well known with its diverse communities, including rural and urban living people (GAS, 2020). To achieve the objectives of this study, a field research methodology was conducted that employed survey samples of 325 people being randomly selected from the province.

Specially designed questionnaires were used to collect the designated primary data. The questioners involved two major parts, with the first being related to demographic features of surveyed people and the second was about the social awareness towards antibiotics proper use, knowledge about their use guidelines and their misuse impacts on environment and human health. Also, the study was based on enumerating technique to quantify the answers of respondents. Moreover, full praises were considered to the participants by carefully choosing the proper style of the questions and their accuracy views to the targeted information. In addition, popular scientific meanings between the questions were counted. Finally, data collection was done in 6 months period from December 2018 to May 2019.

### *Questionnaires components and their measurements*

#### *Demographic features*

These features involved 13 variables (i.e., independent variable, X1 to X13) measuring the demographic characteristics of investigated people. These variables are as follows:

- X1, gender (i.e., female (1) and male (2)).
- X2, place of residence (i.e., rural area (1) and urban area (2)).
- X3, age (i.e., person's lived years).
- X4, marital status (i.e., single (1), divorced (2), widow (3) or married (4)).
- X5, family size (i.e., total number of family members living together).

- X6, father's age (i.e., real number of years that father has lived so far).
- X7, father's education (i.e., illiterate (1), can read & write (2), primary degree (3), elementary degree (4), secondary degree (5), bachelor's degree (6), master's degree (7) or doctorate degree (8)).
- X8, father's occupation (i.e., unemployed (1), retired (2), teacher (3), governmental employee (4), own business (5), private sector (6) or high ranked employee (7), including university staff member, manger, engineer etc.).
- X9, mother's age (i.e., real number of years that mother has lived so far).
- X10, mother's education (i.e., illiterate (1), can read & write (2), primary degree (3), elementary degree (4), secondary degree (5), bachelor's degree (6), master's degree (7) or doctorate degree (8)).
- X11, mother's occupation (i.e., unemployed/household (1), retired (2), teacher (3), governmental employee (4), businesswoman (5), private sector (6) or high ranked employee (7), including university staff member, manger, engineer etc.).
- Community engagement (X12) levels that were measured by 6 questions to assess the surveyed person participation in the community affairs. The answers to these questions were specifically rare, sometimes, or always. The answer to each question was then nominated with a degree of 1, 2 or 3, respectively, or opposite in accordance with the meaning of the question.
- Open mind (X13) levels that were measured by 10 questions to assess here the concerns of surveyed people to surrounding issues and their readiness to accept others' opinions. These questions were specified with answers of rare, sometimes, or always. The answer to each question was then given a degree of 1, 2 or 3, respectively, or opposite in accordance with the meaning of the question.

#### ***Awareness towards antibiotic proper use, knowledge about antibiotic use guidelines and antibiotic misuse impacts on environment and human health***

These aspects were measured by 41 questions with answers being specified with three options (i.e., rare, sometimes, or always). These questions were divided into three categories that were designated to measure the perception levels of surveyed people towards 1- antibiotics proper use and conducts of their leftovers (i.e., 11 questions), 2- knowledge about their use guidelines and risks of their random use (i.e., 10 questions), and 3- attitudes regarding antibiotics misuse impacts on environment and human health (i.e., 20 questions). The answer to each question was then given a degree of 1, 2 or 3, respectively, or the opposite in accordance with the implication of the question. Afterwards, the degree values average of the three categories was then anticipated as an overall value of the awareness levels of participants towards the negative impacts of antibiotic misuse (i.e., dependent variable, Y) on environment and human health. This was regarded as a quantitative value to such aspects.

#### ***Interactions between demographic features with antibiotics misuse and their impacts on environment and human health***

The correlation between the demographic features, as independent variables (i.e., X1-X13) with the awareness of participants towards the negative impacts of antibiotics misuse, as a dependent variable (i.e., Y), on the environment and human health was also verified. It was done to estimate the contributions of each independent variable on such awareness and hence on the negative impacts on the environment and human health.

#### ***Statistical analysis***

After collecting the targeted information, answers of correspondents were thoroughly reviewed and obtained responses were tabulated into Statistical Package for Special Sciences (SPSS) 25.0 software program for proper statistical analysis. Meanwhile, the studied people demographic data were analyzed using descriptive statistics and their results were presented as numbers and percentages.

## **Results**

### ***Demographic characteristics of investigated people***

#### ***Demographic features***

Main demographic attributes (i.e., independent variables, X1 to X13) of participants indicated that the genders of surveyed people

(X1) were 220 females (67.7%) and 105 males (32.3%), with 207 people (62.7%) living in urban areas and 118 people (36.3%) living in rural areas (X2). Their ages(X3) ranged from 18 years to 28 years, with an average of 21 years ( $\pm 1.63$ ). These ages were categorized into three classes (i.e., first of 18-21 years, second of 21-24 years and third more than 24 years), with a total number of 138 (42.5%), 160 (49.2%) and 27 (5.3%) persons, respectively. The marital status (X4) showed that 265 persons (82.5%) were single, 58 persons (17.8%) were married, two people (0.7%) were divorced and none was a widow wither male or female. The size of family (X5) ranged between 3 and 14 people with an average of 8.03 persons per family ( $\pm 2.04$ ). The family size was also divided into three classes (i.e., first of 3-7 persons, second of 7-11 persons and third of 11-14 persons). The total members of family in each class were 62 (19.1%), 222 (68.3%) and 41 (12.6%), respectively. This indicates that most studied people fall within the last two categories (80.9%).

The fathers' collected data showed that their ages(X6) varied from 35 years to 68 years with an average of 53.4 years ( $\pm 6.3$ ). The range of their ages was divided into three classes, including first class of 35-46 years (i.e., 50 persons, 15.4%), second class of 46-57 years (i.e., 200 persons, 61.5%) and third class of 57-68 years (i.e., 75 persons, 23.1%). The fathers' education (X7) showed a range of variations as 30 illiterates (9.2%), 16 reads and writes (4.9%), 71 with a primary certificate (21.8%), 50 with an elementary certificate (15.4%), 87 with a secondary certificate (26.8%), 69 with a bachelor's degree (21.2%) and just one with a higher education degree (0.3%). These data indicate that most fathers (78.2%) were with a secondary certificate or less in comparison with the 21.8% who held a university degree or higher. The fathers' occupation (X8) data were 76 retired (23.4%), 70 in public sector (21.5%), 63 businessmen (19.4%), 46 teachers (14.2%), 41 in privet sector (12.6%), 28 other occupations (8.6%) and 4 unemployed (1.2%). This reveals that the studied people were involved in all possible occupations with most of them (i.e., 64.3%) were in the first three categories.

However, the mothers' obtained data of studied people indicated that their ages(X9) ranged between 30 years and 64 years with an average of 46.8 years ( $\pm 6.54$ ), indicating they are younger than fathers. The mothers' ages data were divided into three classes, including the first class of 30-41 years (i.e., 67 mothers, 20.6%), the second class of 41-52 years (i.e., 188 mothers, 57.8%) and the third class of 52-54 years (i.e., 70 mothers, 12.6%). The mothers' education (X10) data were 41 illiterates (12.6%), 14 reads and writes (4.3%), 51 with a primary certificate (15.7%), 39 with an elementary certificate (12.0%), 107 with a secondary certificate (32.9%), 72 with a bachelor's degree(22.2%) and just one with a higher education degree (0.3%).The mothers' occupation (X11) data indicated that 174 households (53.5%), 42 teachers and business-ladies (12.9%), 27 in a private sector (8.3%), 21 retired (6.5%) and 19 in a governmental sector (5.8%). This indicates that most of mothers are nonworking women (i.e., household women).

These demographic data of participants (X1 to X11) were generally in lines with the population indices of the KSA citizens (GAS, 2020). These indices indicate that the percentage of Saudi youths (i.e., 15-34 years old) is 36.7%, being compared to the 30.3% of 0-14 years (i.e., children), and 33% over 35 years (i.e., elderly). In 2020, 51% of these youths were males and 49% were females. Their marital status was 66.23% unmarried, 32.45% married, 1.27% divorced and 0.05% widows. The educational status showed enormous improvement in Saudi youths between the years of 2007 and 2017, as illiterate percentage decreased from 3.7% to 0.5%. Secondary educated youths in 2019 were 99.8%, with 99.6% males and 100% females. The labor force statistics revealed that 47% of Saudi youths were employed (i.e., 69% males and 31% females). This reveals that the investigated people are a delegate to the Saudi Arabian community.

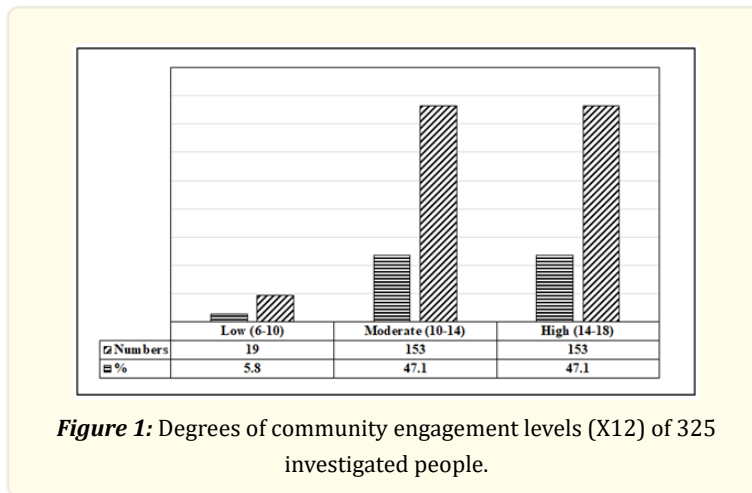
### **Community engagement**

The data of community engagement (X12) levels of surveyed people are outlined in Table 1 that includes 6 questions measuring the investigated people engagements with their community affairs. Their answers were with 3 categories (i.e., always (A), sometimes (S), and rare (R)). The table shows that there are marked variations in the responses of studied people toward such attribute. These variations are briefed in the calculated degrees of the community engagement levels presented in Figure 1 that includes 3 levels (i.e., low (6-10), moderate (10-14), and high (14-18)). It can be seen from the Figure that most of respondents were engaged in levels between moderate (47.1%) and high (47.1%), implying that most of the studied people (i.e., 94.2%) were socially active in their community.

<b>Levels of community engagement*</b>	<b>A</b>	<b>S</b>	<b>R</b>	<b>T</b>
Contributing to solving conflicts between friends	71	189	69	325
Participating with friends and neighbors in their events	62	174	89	325
Sharing tools and machines with friends and neighbors	188	113	24	325
Cooperating with friends and neighbors in achieving duties	109	116	100	325
Talking about problems facing me with friends and neighbors	180	106	39	325
Offering solutions to problems facing me or friends or neighbors	146	149	30	325

\* A, S, R, & T refer to always, sometimes, rare, and total, respectively.

**Table 1:** Community engagement levels of investigated people.



**Figure 1:** Degrees of community engagement levels (X12) of 325 investigated people.

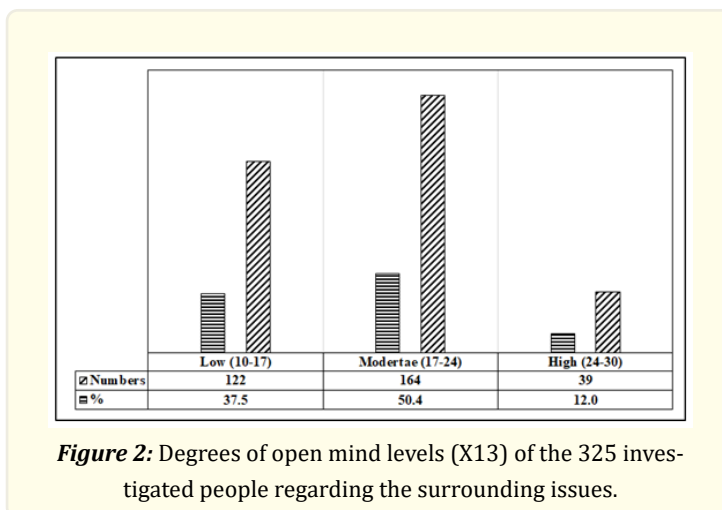
**Open mind**

The data of open mind (X13) levels of the investigated people are outlined in Table 2 that includes 10 questions measuring their sincerity and concerns to the surrounding issues. The answers to these questions were a choice of three options that are always (A), sometimes (S), and rare (R). Table 2 indicates that the investigated people differed in their responses to such attribute, indicating the variations in their open mind to community affairs. The answers were then converted into degrees of 3 levels (i.e., low (10-17), moderate (17-24), and high (24-30)) that are presented in Figure 2. Obtained data in Figure 2 reveals that the degrees of their open mind aspects were in a descending order of moderate (50.5%), followed by low (37.5%) and then high (12.0%). This implies that most of the respondents were moderate in their concerns to surrounding affairs, which is possibly explained by the variations observed in their demographic features.

<i>Levels of open mind of surveyed people to surrounding issues*</i>	<i>A</i>	<i>S</i>	<i>R</i>	<i>T</i>
Visiting friends in neighborhoods and other villages	76	155	94	325
Visiting friends in other counties and other regions	23	73	229	325
Viewing TV general talk-show programs	53	183	119	325
Watching TV health programs	27	139	159	325
Listening to radio informative programs during driving car	40	82	203	325
Preferring reading health extension materials	37	143	145	325
Reading health instructions produced by Ministry of Health	64	139	122	325
Visiting health care centers to get some advice	24	85	216	325
Interacting with health programs held in public areas (e.g., malls)	13	72	240	325
Attending some lectures organized by Ministry of Health	28	115	182	325

\* A, S, R, & T refer to always, sometimes, rare, and total, respectively.

**Table 2:** levels of open mind(X13) of investigated people to the surrounding issues.



**Figure 2:** Degrees of open mind levels (X13) of the 325 investigated people regarding the surrounding issues.

These demographic measurements therefore indicate that the participants were well engaged in the community affairs (X12) (Table 1 and Figure 1). This signifies the volunteering potentials of the respondents in harmony with the KSA 2030 strategic vision that aims to tally million volunteers a year by the 2030, as an indicator of an ambitious nation (Unified National Platform, 2021). However, the interests of respondents (X13) were scant to the surrounding affairs and others’ views (Table 2 and Figure 2). This is probably due to their deficit communication skills, which appears to be a crucial barrier in several Saudi social aspects, such as health affairs (Al-Zahrani et al., 2015; Alsaad et al., 2016; Alnasser et al., 2017; Nourein et al., 2021). These authors also advocated that such skills should be strategically acquainted in the national educational programs.

***Awareness towards antibiotics proper use and their leftovers, knowledge about antibiotic use guidelines, and knowledge about impacts of misuse and misconduct of antibiotic on environment and human health***  
***Awareness towards proper uses and conduct of antibiotics and their leftovers***

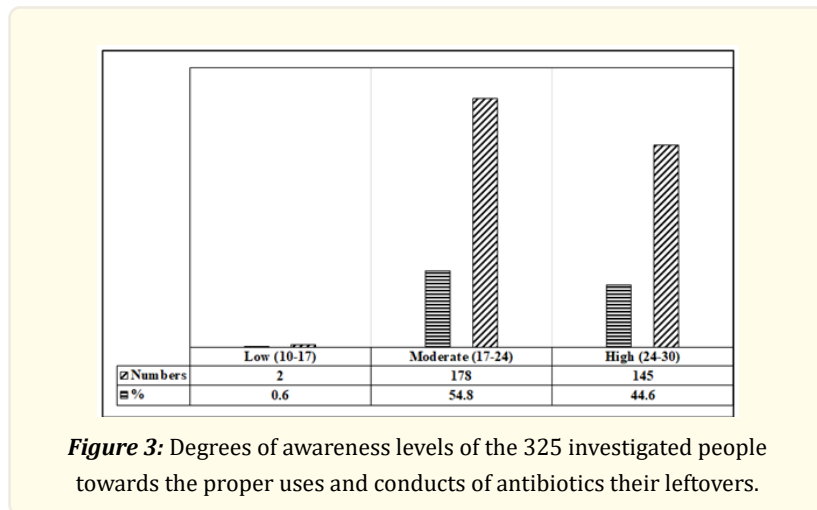
The awareness levels of investigated people towards the proper uses and conduct of antibiotics and their leftovers were measured using 11 questions that are outlined in Table 3. The answers to such questions were classified into 3 categories (i.e., always (A), sometimes (S), and rare (R)). Table 3 shows that the respondents vary in their response to such issue. Such variations in the polled people were translated into 3 degrees of low (10-17), moderate (17-24), and high (24-30) that are presented in Figure. The figure reveals that

most participants (99.4%) were of moderate (54.8%) and high (44.6%) degrees in their awareness to such aspects, which implies that they are adequately aware towards the proper uses and conducts of antibiotics and their leftovers appropriate conduct procedures.

<b>Awareness levels of surveyed people to proper uses and conducts of antibiotics and their leftovers*</b>	<b>A</b>	<b>S</b>	<b>R</b>	<b>T</b>
Stop using them aiming to future protection from diseases	52	212	61	325
Stick to decided dosages in prescription to prevent spreading of microbes resistant to antibiotics	124	171	30	325
Seek physicians' advice before using them	188	117	20	325
Seek pharmacists' advice before using them	104	182	39	325
Give them to another patient to use on basis of my experience	115	98	112	325
Keep them for future use when feeling same symptoms without physician's advice	152	105	68	325
Dispose them in drainage system particularly those in liquid forms	184	101	40	325
Dispose them by burying in soil	31	280	14	325
Dispose them using a plastic bag and then in trash container	205	100	20	325
Use a face mask when having cold or flu symptoms	163	76	86	325
Prevent infections by exercising good health practices (e.g., washing hands)	121	167	37	325

\* A, S, R, & T refer to always, sometimes, rare, and total, respectively.

**Table 3:** Awareness levels of investigated people to proper uses and conducts of antibiotics and their leftovers.



**Figure 3:** Degrees of awareness levels of the 325 investigated people towards the proper uses and conducts of antibiotics their leftovers.

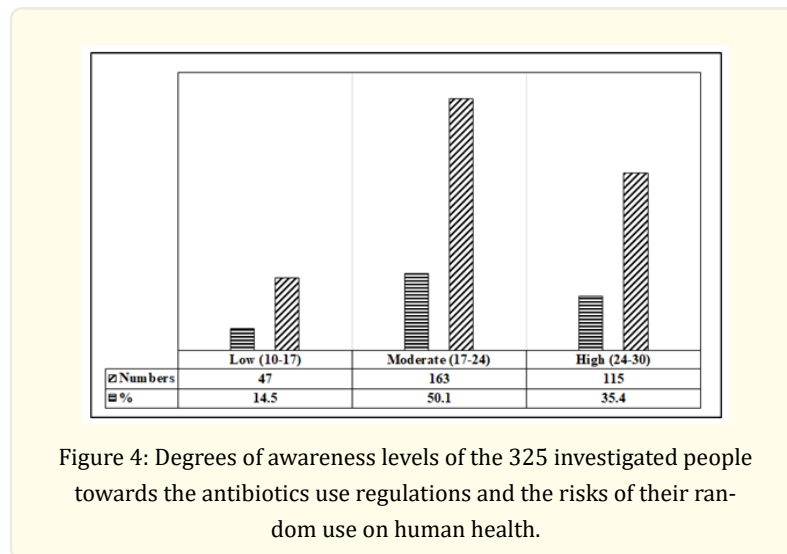
**Knowledge towards use guidelines of antibiotics and their random use risks on human health**

The knowledge levels of the respondents to the use guidelines of antibiotics and their random use risks on human health were measured using 10 questions that are summarized in Table 4. The answers to these questions were categorized into 3 levels (i.e., always (A), sometimes (S), and rare (R)). Table 4 indicates that there are noticeable variations in the respondents towards such aspects. These variations are transformed into 3 degrees of low (10-17), moderate (17-24), and high (24-30) levels, as seen in Figure 4. The figure reveals that the perceptions of the polled people were in a descending order of moderate (50.1%), high (35.4%) and low (14.5%). This result infers that most of surveyed people (85.5%) were aware of the antibiotics use guidelines and their random use risks on human health.

<i>Awareness levels of surveyed people to antibiotics use regulations and risks of their random use*</i>	<i>A</i>	<i>S</i>	<i>R</i>	<i>T</i>
Stick to proper concentration indicated on package	208	18	99	325
Stick to right intake duration of medication	257	15	53	325
Stick to right dosage quantity decided by the physician	280	13	32	325
Stick to proper number of tablets every time taking them	237	18	70	325
Stick to expiration date indicated on the package	225	66	34	325
Random use causes longer stays in hospital	89	42	194	325
Random use increases costs of diagnosis and medications	85	13	227	325
Random use increases death among sick people	64	72	189	325
Random use speeds up existence of microbes resistant to antibiotics in environment	200	29	96	325
Misuse them develops small infections to levels of death	130	59	136	325

\* A, S, R, & T refer to always, sometimes, rare, and total, respectively.

**Table 4:** Levels of investigated people awareness to antibiotics use regulations and the risks of their random use on human health.



**Figure 4:** Degrees of awareness levels of the 325 investigated people towards the antibiotics use regulations and the risks of their random use on human health.

**Knowledge about impacts of misuse and misconduct of antibiotics on environment and human health**

The knowledge levels of investigated people regarding the impacts of misuse and misconduct of the antibiotics on the environment and human health were measured using 20 questions that are outlined in Table 5. The answers to these questions were categorized into 3 levels (i.e., always (A), sometimes (S), and rare (R)). Table 5 reveals that there are distinctive variations in the perceptions of polled people towards such aspect. These variations were then calculated in degrees of 3 levels that are low (20-33), moderate (33-46), and high (46-60) (Figure 5). The degrees of the awareness levels of investigated people towards such issues were mostly moderate (68.3%), followed by low (26.8%) and then high (4.9%). Such results imply that most surveyed people (95.1%) had inadequate knowledge to the negative consequences of antibiotics misuse and misconduct on the environment, signifying the needs to improve their perceptions towards such issue.

The data in Tables (3 to 5) and Figures (3 to 5) indicate that the surveyed people were short in their social awareness towards antibiotics proper use, knowledge about their use guidelines, and their misuse impacts on environment, respectively. The overall degrees

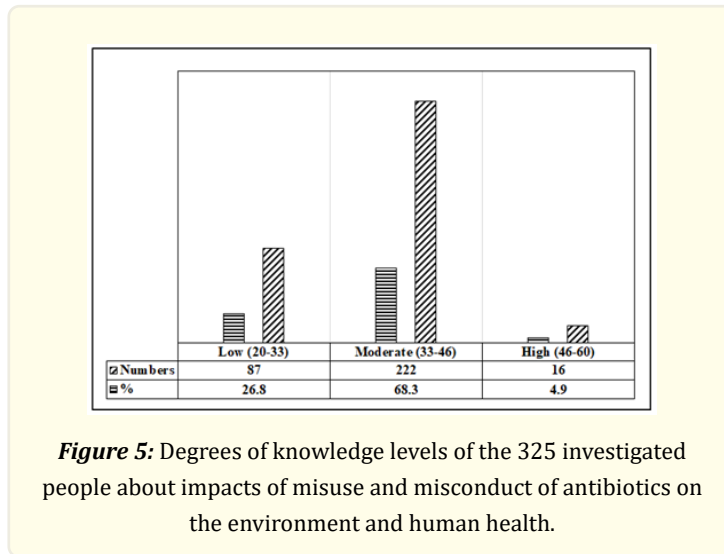


of these aspects were mostly moderate (57.8%), followed by high (28.4%), and then low (13.8%) (table 6). These findings suggest that participants retain in a way or another an attitude and knowledge insufficient to properly use and handle the antibiotics, which consequently impose some undesirable impacts on environment and hereafter human health. Various investigators indicated that antibiotics misuses and misconducts in KSA evoked fears to authorities and concerned people (Al-Mustafa and Al-Ghamdi, 2002; El Zowalaty et al., 2016; Alharbi et al., 2017; Alhormaidan et al., 2021). Al-Mustafa and Al-Ghamdi (2002) argued that misuse of antibiotics in KSA poultry industry poses a serious health threat to the public. This implies that some enhancements to the perceptions of Saudi citizens towards aspects of antibiotics proper use and conducts are inevitably desired to sustain the environment and its components and hence protect the public health.

<i>Levels of investigated people acquaintance regarding the impacts of misuse and misconduct of antibiotics on environment and human health*</i>	<i>A</i>	<i>S</i>	<i>R</i>	<i>T</i>
Using them with any disease speeds up recovery	69	133	123	325
They protect from virus diseases, as influenza	136	120	69	325
Their use must be by a physician's prescription	261	56	8	325
Must not use them before being sick to prevent being ill	211	75	39	325
Using them increases human's immunity	67	117	141	325
Must take them in the exact times decided by the physician	261	52	12	325
Not taking them in right time decided by physician causes no harm	70	132	123	325
Must complete their dose even after feeling better	98	93	134	325
Must stop using them when feeling improved	167	75	83	325
Must use the whole package following the physician's advice	155	103	67	325
Storing them in room-temperature in summer season causes no damage to the package	43	88	194	325
Their excessive uses threaten food safety	244	65	16	325
Repeating their use ignoring regulations produces microbes hard to treat in future	187	120	18	325
Their random use causes their future failure to help people from illness recovery	215	92	18	325
Must seek expert's advice (e.g., veterinarian) before giving them to animals	243	67	25	325
Using them in farm for animals or plants has negative impact on human health	120	167	38	325
Their residual presence in foods impairs human after eating them	200	112	13	325
Using them without real need harms the person's health wither a child or an adult	231	68	26	325
Not everyone can buy them due to their high cost	50	160	115	325
Must discard their leftovers in drainage system	70	87	168	325

\* A, S, R, & T refer to always, sometimes, rare, and total, respectively.

**Table 5:** Knowledge Levels of investigated people about impacts of misuse and misconduct of antibiotics on the environment and human health.



Degrees	Low (41-69)	Moderate (69-95)	High (95-123)	Total
Numbers	45	188	92	325
%	13.8	57.8	28.4	100

**Table 6:** Overall degrees of awareness towards the antibiotics proper use, knowledge about their use guidelines, and antibiotics misuse impacts on environment.

**Interactions between demographic features with antibiotics misuse and their impacts on environment and human health**

The beneath stated equation shows the result of the correlation between demographic features, as independent variables (i.e., X1 to X13) with the awareness of participants towards negative impacts of antibiotics misuse and misconducts, as a dependent variable (i.e., Y). As indicated earlier (section 3.3.3), this was done to assess the individual contribution of these independent variables on the process of these impacts on the environment and human health.

$$Y=37.10+1.51X2+1.04X1+0.98X4+0.56X8+0.52X3+0.50X11+0.45X10+0.44X12+0.27X7-0.06X9$$

Where

Y is the social awareness towards negative impacts of antibiotics misuse and misconducts on environment and human health.

X1, X2, X3, X4, X7, X8, X9, X10, X11, and X12 are demographic features of gender, place of residence, age, marital status, father’s education, father’s occupation, mother’s age, mother’s education, mother’s occupation, and community engagement, respectively.

It may be seen from the equation that the correlation between these various variables was high with value of  $r^2 = 0.872$ . It is also apparently observed from the equation that the independent variables of X5, X6, and X13 (i.e., family size, father’s age, and open mind, respectively) were not included, as their effects were small enough to be neglected. Nonetheless, the other X independent variables varied in their effects on the Y dependent variable. Their effects were mostly positive with a descending order of X2 (1.51), X1 (1.04), X4 (0.98), X8 (0.56), X3 (0.52), X11 (0.50), X10 (0.45), X12 (0.44), and X7 (0.27). Yet, the X9 variable was the only variable with a negative impact and relatively small (-0.06) as compared with others.

These values disclose the role of each independent variable in their effects on the participant’s awareness towards the adverse

consequences of antibiotics misuse and misconducts on the environment and human health. Considering these factors with each one being given its deserved weight; it is plausible to suggest that a strategy ought to be carefully adopted to improve the social awareness towards antibiotics misuse and misconducts to sustain the environment and protect human health. Such strategy had been proposed by other researchers (Alhomoud et al., 2017; Barker et al., 2017) to address issues of antibiotics and other related medications jeopardizing environment or human health. The proposed strategy ought to employ some educational and extensional programs to all recipients to improve their attitudes and knowledge towards proper use and conduct of antibiotics.

## Discussion

In current study, the outlined demographic features of surveyed people (i.e., X1 to X11 parameters) proved to satisfactorily represent the inhabitants living in the study area of the Eastern Province, KSA (GAS, 2020). These demographic data also revealed that the participants were well-mannered in their community engagements (i.e., X12 parameter), signifying their thriving public volunteering potential (Unified National Platform, 2021). Yet, they were meager in their open mind characters (i.e., X13 parameter), implying their limited social community skills (Al-Zahrani et al., 2015; Alsaad et al., 2016; Alnasser et al., 2017; Nourein et al., 2021). Therefore, these data reasonably imitate the wide variations in the metropolitans and demographic features of the province, as the largest in area and one of the most populated provinces in KSA (MMRA, 2018).

Moreover, the findings of this study disclosed that the opinions of the participants were mostly unprivileged towards the antibiotics proper use, knowledge about their use guidelines, and antibiotics misuse impacts on environment and human health (i.e., Y parameter), having overall moderate to low degrees. This suggests that their perceptions towards such matters require some improvements to avoid unwelcome consequences on environment and human health. Protection of environment and so human health is a crucial issue well considered in the KSA 2030 vision that comprises three main goals, among which is building a more vibrant society targeting to reduce pollution of surrounding resources and their components to motivate environmental sustainability (Unified National Platform, 2021). Alshuwaikhat and Mohammed (2017) proposed that setting up broad assessment procedures to determine the progress towards the sustainability is a critical step to achieve the success of the KSA 2030 vision. The authors also hinted at that the success of the vision depends on the effective participations and empowerments of relevant stakeholders at all levels. It is also worth to indicate that obstructing environmental pollution resulting from agricultural activities is a sincere concern of several investigators and authorities in the country (GAMEP, 2017; MEWA, 2018; Almadini et al., 2021; Alsherif et al., 2022).

In addition, there was a good correlation (i.e.,  $r^2=0.872$ ) between the independent variables of demographic features (i.e., X1 to X13) with the dependent variable of social awareness about the negative impacts of antibiotics misuse and misconducts (i.e., Y) on the environment and human health. This result signifies the great interactions between these variables, which proposes that the progress in social understanding and knowledge to protect environment and human health from antibiotics misuses and misconducts is a vital issue and demands a well-planned strategy.

The proposed strategy is presumed to instigate some educational and extension agendas that target all related people; thus, their attitudes and knowledges about the antibiotics proper uses and conducts are improved to praise issues of environmental sustainability and human health safety (Al Akhali et al., 2013; AL-Mohamadi et al., 2013; Alhomoud et al., 2017; Barker et al., 2017; Marzan et al., 2021; Karuniawati et al., 2021;). Khan et al. (2020) reported in their study aimed to evaluate the Saudis' awareness to environmental sustainability that improving the awareness towards such issue could be attained by employing further events and efforts on environmental topics. Deo et al. (2019) concluded that covering topics related to antibiotics and their judicial usages in educational curricula is capable to cause marked progresses in knowledges, attitudes, and practices of related people at all levels. Marzan et al. (2021) also stated that introducing short educational materials regarding the risk impacts of antibiotics to environment will improve recipients' awareness towards their proper uses and conducts. Furthermore, Al Akhali et al. (2013) advised that educating both patients and practitioners must be in harmony with each other to improve the community insights regarding the proper usages and conducts of antibiotics.

Moreover, it may be emphasized from the findings that there are inevitable needs to set legislations controlling the antibiotics sales and usages and to strictly implement them as a key component of the proposed strategy enhancing the social attitudes and knowledge about the negative impacts of antibiotics misuse and misconduct on environmental sustainability and human health safety. Such opinion was also advocated by other investigators (Sahoo et al., 2010; AL-Mohamadi et al., 2013; El Zowalaty et al., 2016; Zowawi, 2016; Al-Yasseri et al., 2019; Nisabwe et al., 2020; Karuniawati et al., 2021). However, it is also worth to assure that the success of these legislations necessitates full synergic efforts between concerned sectors of environmental and health authorities, law organizations, policy makers and civic parties to achieve the success of their targeted management, supervision, and implementation activities as well as enforcements of penalties to those violating them. This was also claimed by other scientists (El Zowalaty et al., 2016; Zowawi, 2016; Alhomaidan et al., 2021). Nisabwe et al. (2020) provoked that there should be firm policies that strictly control the selling and consuming processes of antibiotics without a therapeutic prescription.

In addition, various scientists insinuated that enhancements of social perceptions towards improving usage and conduct systems of antibiotics to sustain environment and to safeguard human lives are crucial challenges worldwide. These challenges appeared on debates due to the negative impacts of antibiotics misuses and misconducts on the natural resources. Taking into accounts the using benefits and desires of antibiotics, several studies implied that the incidents of their residues in the environment are global concerns demanding collective attempts and efforts to reduce the concentrations of such residues and hence impair their negative impacts on environment and human health (Li et al., 2017; Grenni et al., 2018; Manage, 2018; Manyi-Loh et al., 2018; Ben et al., 2019; Nisabwe et al., 2020; Polianciuc et al., 2020; Serwecińska, 2020). In addition, further studies suggested that residues in the environment from humans and farms will plausibly contain antibiotics and antibiotic resistant microbes that are considerable a polluting source to the surrounding environment and its components (Grenni et al., 2018; Manyi-Loh et al., 2018; Polianciuc et al., 2020; Serwecińska, 2020).

Nevertheless, Zowawi (2016) suggested that there are several challenges in KSA to obstruct the emergence and reproduction of such antibiotic resistant microbes in the environment. The author also proposed that such challenges should incorporate collective efforts from different authorities to successfully control the presence of these microbes in the environment, emphasizing on the real needs to raise public awareness to limit the improper usages and handlings of antibiotics.

## Conclusions and recommendations

It may be concluded from the findings of this study that the randomly chosen sample of the 325 surveyed people was reasonably featuring the metropolitan and demographic broad variations in the Eastern Province of the KSA. The obtained data also promoted that most of the respondents were unprivileged in their perspectives to the antibiotics proper use, the knowledge towards their use guidelines, and the negative impacts of antibiotic misuses and misconducts on the environment and hence on the human health. The demographic features were highly correlated (i.e.,  $r^2=0.872$ ) with the perceptions of surveyed people about the impacts of antibiotic misuses and misconducts on the environment and human health, inferring the real needs to employ a strategy to improve their concepts regarding such aspect. The proposed strategy ought to involve some educational and extensional programs as well as setting and strictly implementing legislations controlling the selling and managing the antibiotics. The success of the legislations requires well integrated efforts between all related sectors, thus targeted environmental sustainability in the country is conceivably attained.

## Conflict of interests

The authors proclaim that there is no conflict of interests in any commercial or financial issue.

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**Volume 2 Issue 5 May 2022**

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