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Public response to MERS-CoV in the Middle East: iPhone survey in six countries



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ABSTRACT

Gulf Cooperation Council (GCC) countries bear the heaviest brunt of MERS-CoV. This study aims to compare public awareness and practice around MERS-CoV across GCC countries. A cross-sectional survey was conducted using the Gulf Indicators (GI) smartphone app among people in the six GCC countries, namely Saudi Arabia, Kuwait, the United Arab Emirates, Qatar, Bahrain, and Oman.

A total of 1812 participants recruited. All were aware of MERS-CoV, yet the perception and practice around MERS-CoV varied widely between countries. Over two thirds were either "not concerned" or "slightly concerned" about contracting MERS-CoV; believing that they were under Allah's (God's) protection (40%) was the most cited reason. While 79% were aware that the disease can transmit through droplet from infected person, only 12% stated that MERS-CoV transmits via camels; people in Saudi Arabia were better aware of the transmission. Nevertheless, only 22% of respondents believed that camels are the zoonotic reservoir of MERS-CoV. Those who were concerned about contracting MERS-CoV (aOR: 1.6, 95% CI: 1.2–2.1, $p < 0.01$) and those who thought MERS-CoV to be a severe disease only for those with high-risk conditions (aOR: 1.5, 95% CI: 1.1–2.1, $p < 0.01$) were more likely to believe that camels are the zoonotic source. However, residents of KSA (aOR: 0.03, 95% CI: 0.01–0.07, $p < 0.01$), UAE (aOR: 0.01, 95% CI: 0.004–0.02, $p < 0.01$) and Kuwait (aOR: 0.03, 95% CI: 0.01–0.07, $p < 0.01$) were less likely to believe that camels are the main zoonotic source compared to respondents from the other countries. Hygienic measures were more commonly adopted than avoidance of camels or their raw products, yet there was a discrepancy between the countries.

This study highlights that despite being aware of the ongoing MERS-CoV epidemic; many people lack accurate understanding about MERS-CoV transmission, prevention, and are not fully compliant with preventive measures.

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Background

Middle East respiratory syndrome coronavirus (MERS-CoV) is a severe respiratory infection which has infected over 1888 people in 27 countries [1]. Since its first discovery in Saudi Arabia in 2012 [2], MERS-CoV has spread to neighboring Gulf countries (Table 1)

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Table 1
Total number of MERS-CoV cases in GCC countries

Country name	Total population	Number of cases	Number of fatalities (%)
Saudi Arabia	31,540,000	1549	643 (42)
United Arab Emirates (UAE)	9,157,000	80	12 (15)
Kuwait	3,892,000	4	2 (50)
Qatar	2,235,000	16	5 (31)
Bahrain	1,377,000	1	0 (0)
Oman	4,490,000	7	3 (43)

† As of 1st February 2017, the total number of MERS-CoV cases globally is 1888 (WHO <http://www.who.int/emergencies/mers-cov/en/>).

World Health Organization (WHO) and the US Centers for Disease Control and Prevention (CDC). These recommendations include facemask use, hand hygiene, cough etiquette, and avoidance of close contact with camels and consumption of their raw products [6,7], needing public participation and subsequent investigation to quantify their uptake and effects.

Few studies have attempted to examine the knowledge and practices around MERS-CoV among members of the public and health care workers (HCWs) and that is only in Saudi Arabia, the hotspot of MERS-CoV [8–11]. However, no study has compared public understanding and behaviors around MERS-CoV across the Gulf countries. Also, no study has explored knowledge and practices about the risk of camel exposure among the general public. Such data are required for transnational comparisons, designing mitigation plans, research and sharing accountability across the countries. Moreover, it can also provide lessons for the future in relation to public willingness to adopt prevention behaviors and support related policies against emerging diseases. To this end, we have conducted a cross-sectional study to examine public awareness about MERS-CoV and compare public adoption of preventive practices including non-pharmaceutical behaviors (e.g. hand hygiene) and exposure to camels in response to the epidemic MERS-CoV among residents of Gulf Cooperation Council (GCC) countries.

Methods

Study design and recruitment method

This was a cross-sectional survey among people aged ≥ 16 years and living in GCC countries, namely, Saudi Arabia, Kuwait, the United Arab Emirates (UAE), Qatar, Bahrain and Oman. The survey was conducted as part of the Gulf Indicators (GI) smartphone app project. The GI is a smartphone app that was published in apple app store in November 2014, to be used as a research data collection platform for cross-sectional and cohort studies targeting users from the GCC countries. This survey was published on the GI platform from July to November 2015. Registered participants who have the app installed on their smartphone devices (voluntarily) received push-notifications (short messages [SMS]-like function) from the app inviting them to open the app and participate in the study, and also reminders were sent to those who did not complete the survey questions [12]. The app has 'built-in' location verification function to guarantee that only users from targeted countries are allowed to register. Each user has a unique device identifier linked to the research database so the user cannot submit any information more than once, and allow anonymous data collection. This method was tested successfully in previous studies [13–15].

After the first push-notification, a reminder was sent once every week to those who did not complete the survey questions. As the data were obtained electronically no user could submit their responses with missing vital information. Electronic informed consent was obtained from all individual participants included in the study.

Data on socio-demographic characteristics of the respondents, perceptions regarding MERS-CoV, and understanding of its risk

Table 2
Demographic characteristics of surveyed participants.

Traits	n (%)
Age in years	
Mean	27.36
SD	± 8.38
Gender	
Male	1485 (82)
Female	327 (18)
Countries	
Kingdom of Saudi Arabia	1105 (61)
Kuwait	253 (14)
United Arab Emirates	203 (11)
Bahrain	98 (6)
Qatar	93 (5)
Oman	60 (3)
Education	
\leq High school certificate	803 (44)
$>$ High school certificate	1009 (56)
Employment statue	
No	237 (13)
Yes	1575 (87)
Government employee	530 (34)
Student	432 (27)
Private sector employee	415 (26)
Business	123 (8)
Home maker	46 (3)
Retired	29 (2)
Smoking status	
No	845 (47)
Yes	967 (53)
Presence of chronic medical conditions	
No	1376 (76)
Yes	436 (24)

from exposure to camels or their raw products were collected in a questionnaire. The questionnaire also assessed the respondents' adoption of protective behaviors including avoidance of contact with camels, consumption of raw camel milk and meat and adherence of using non-pharmaceutical behaviors such as facemask use and hand hygiene.

Sample size

Assuming that at least 50% of the members of public in GCC countries will have the right knowledge about MERS-CoV [8,9], and considering an error margin of 10% to be acceptable for this survey, a minimum sample size of 480 was considered sufficient for this survey, but we aimed to recruit as many participants as possible within the survey period even after the minimum sample size was achieved.

Statistical analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) v.23.0 (SPSS, Inc., Chicago, IL, USA).

Table 3
Knowledge, attitude and perception about MERS-CoV among participants.

	KSA ^a N = 1105 n (%)	Kuwait N = 253 n (%)	UAE ^a N = 203 n (%)	Bahrain N = 98 n (%)	Qatar N = 93 n (%)	Oman N = 60 n (%)	Total (n = 1812)	p Value
Source of MERS-CoV knowledge^b								
Mass media	801 (72)	193 (76)	125 (62)	39 (40)	59 (63)	60 (100)	1277 (70)	<0.01
Social media	404 (37)	33 (13)	26 (13)	58 (59)	30 (32)	36 (60)	587 (32)	<0.01
Family physicians	265 (24)	59 (23)	85 (42)	22 (22)	17 (18)	0 (0)	448 (25)	<0.01
Family/friends	280 (25)	46 (18)	37 (18)	45 (46)	24 (26)	15 (25)	447 (25)	<0.01
Ministry of Health website	220 (20)	33 (13)	17 (8)	32 (33)	14 (15)	8 (13)	324 (18)	<0.01
Transmission mode^b								
Through coughing or sneezing (large droplet)	891 (81)	185 (73)	171 (84)	61 (62)	76 (82)	55 (92)	1439 (79)	<0.01
Through direct contact with infected person	260 (24)	31 (12)	24 (12)	39 (40)	11 (12)	8 (13)	373 (21)	<0.01
Air borne transmission (droplet nuclei)	162 (15)	5 (2)	17 (8)	26 (27)	8 (9)	6 (10)	224 (12)	<0.01
Through direct contact with infected camel	141 (13)	18 (7)	13 (6)	19 (19)	12 (13)	6 (10)	209 (12)	<0.01
Through drinking raw camel milk	167 (15)	39 (15)	22 (11)	61 (62)	12 (13)	18 (30)	319 (18)	<0.01
Through eating uncooked camel meat	659 (60)	150 (59)	149 (73)	69 (70)	66 (71)	35 (58)	1128 (62)	<0.01
Through touching contaminated surface	677 (61)	141 (56)	164 (81)	39 (40)	70 (75)	41 (68)	1132 (63)	<0.01
Through consumption of contaminated food	624 (56)	177 (70)	149 (73)	70 (71)	65 (70)	2 (3)	1087 (60)	<0.01
Camels are the main zoonotic reservoir								
Yes	261 (24)	60 (24)	17 (8)	9 (9)	9 (10)	50 (84)	406 (22)	<0.01
No	448 (41)	50 (31)	93 (46)	31 (32)	31 (33)	5 (8)	688 (38)	<0.01
Unsure	396 (36)	113 (45)	93 (46)	50 (59)	53 (57)	5 (8)	718 (40)	<0.01
Risk of diseases from drinking raw camel milk								
No to little risk	282 (26)	46 (18)	76 (37)	23 (23)	32 (34)	3 (5)	462 (26)	<0.01
Moderate to high risk	326 (29)	54 (21)	62 (31)	21 (21)	27 (29)	16 (27)	506 (28)	<0.01
Do not know	497 (45)	153 (60)	65 (32)	54 (55)	34 (37)	41 (68)	844 (47)	<0.01
MERS-CoV body part affect								
Brain	58 (5)	3 (1)	39 (19)	4 (4)	6 (6)	1 (2)	111 (6)	<0.01
Gastrointestinal tract	90 (8)	9 (4)	39 (19)	6 (6)	3 (3)	8 (13)	155 (9)	<0.01
Kidneys	69 (6)	8 (3)	44 (22)	9 (9)	12 (13)	7 (12)	149 (8)	<0.01
Respiratory tract	460 (42)	85 (34)	35 (17)	39 (40)	31 (33)	21 (35)	671 (37)	<0.01
Do not Know	428 (39)	148 (58)	46 (23)	40 (41)	41 (44)	23 (38)	726 (40)	<0.01
Risk perception of MERS-CoV severity^b								
Not severe for anyone	188 (17)	85 (34)	56 (28)	29 (30)	32 (34)	30 (50)	421 (23)	<0.01
Only for those with high conditions ^c	404 (37)	49 (19)	67 (33)	25 (26)	26 (28)	18 (30)	589 (33)	<0.01
Severe for everyone	513 (46)	119 (47)	80 (39)	44 (45)	35 (38)	12 (20)	803 (44)	<0.01
Concern of catching MERS-CoV								
Not concerned at all	487 (44)	121 (46)	52 (26)	43 (44)	29 (31)	27 (45)	759 (42)	<0.01
A little concerned	270 (24)	62 (25)	35 (17)	33 (34)	23 (25)	33 (55)	456 (25)	<0.01
Moderately concerned	258 (23)	62 (25)	60 (30)	22 (22)	29 (31)	0 (0)	431 (24)	<0.01
Very concerned	90 (8)	8 (3)	56 (28)	0 (0)	12 (13)	0 (0)	166 (9)	<0.01

^a KSA: Kingdom of Saudi Arabia; UAE: United Arab Emirates.^b Multiple responses.^c Those aged ≥ 65 years and/or have chronic diseases.

Descriptive analysis was used to calculate the response rates and describe the characteristics of the users including their perception about MERS-CoV and compliance to preventive measures. Bivariate analysis was used to quantify the differences across the countries in terms of user characteristics. Logistic regression, using the backward Wald method, controlling for factors, such as age, gender, country, chronic medical conditions, educational level, risk perception and knowledge, was used to investigate variables related to MERS-CoV knowledge and the use of preventive measures.

Ethical approval

This study was reviewed and approved by the Human Research Ethics Committee at King Saud University (Ethics Ref No: 4/2016), Riyadh, Saudi Arabia.

Results

Demographics

A total of 2741 individuals downloaded the app, of whom 1812 (66%) individuals aged 16–75 (median 27) years participated in the

study. A large proportion (61%) of participants were from Saudi Arabia, the others were from five other participating countries (Table 2).

Participants' knowledge and perception about MERS-CoV

All respondents were generally aware of MERS-CoV; mass media (TV, magazines, newspapers) was reported to be the main information source (70%). Thirty seven per cent of respondents stated that MERS-CoV affects the respiratory tract, 23% named other body parts (e.g. brain, stomach and kidneys), while the remaining 40% reported not to know this (Table 3).

Less than half (44%) of respondents reported that the disease is severe and serious for everyone, 33% stated it to be serious only for those with 'at risk' conditions while 23% stated that the disease is not serious for anyone (Table 3). Saudi Arabian participants were 4 times more likely to report MERS-CoV as a serious disease compared to those from other countries (aOR: 4.6, 95% CI: 2.7–8.1, $p < 0.01$).

Over two thirds (67%) of respondents were either "not concerned" or "slightly concerned" about MERS-CoV; the following reasons were stated for this: believing that they were under Allah's

Table 4
Participants' compliance to MERS-CoV protective measures.

	KSA ^a N = 1105 n (%)	Kuwait N = 253 n (%)	UAE ^a N = 203 n (%)	Bahrain N = 98 n (%)	Qatar N = 93 n (%)	Oman N = 60 n (%)	Total (N = 1812)	p Value
Frequent hand washing with soap	564 (51)	79 (31)	49 (24)	52 (53)	32 (34)	24 (40)	800 (44)	<0.01
Frequent hand washing with antibacterial gel	579 (52)	123 (49)	72 (36)	44 (45)	40 (43)	32 (53)	890 (49)	<0.01
Hand washing with soap after shaking hands	517 (47)	68 (27)	36 (18)	32 (33)	26 (28)	22 (37)	701 (39)	<0.01
Covering mouth and nose while coughing	553 (50)	79 (31)	59 (29)	54 (45)	54 (58)	39 (65)	828 (46)	<0.01
Avoidance of touching eyes and mouth	437 (43)	93 (37)	61 (30)	52 (53)	27 (29)	35 (58)	741 (41)	<0.01
Avoidance of close contact with person who have flu symptoms	457 (41)	63 (25)	76 (37)	27 (28)	43 (46)	37 (62)	703 (39)	<0.01
Wearing facemask while visiting someone with flu symptoms	465 (42)	98 (39)	74 (37)	46 (47)	23 (25)	18 (30)	724 (40)	<0.01
Wearing facemask in public or crowded places	273 (25)	34 (13)	43 (21)	39 (40)	25 (27)	22 (37)	436 (24)	<0.01
Avoidance of close contact with camels	633 (57)	80 (32)	139 (68)	53 (54)	72 (77)	43 (72)	1020 (56)	<0.01
Avoidance of drinking raw camel milk	323 (21)	59 (23)	23 (11)	31 (32)	17 (18)	45 (75)	498 (28)	<0.01
Avoidance of consuming uncooked camel meat	260 (24)	40 (16)	35 (17)	20 (20)	21 (23)	18 (30)	394 (22)	0.03
Frequent cleaning of home and workplace surfaces	224 (20)	44 (17)	23 (11)	28 (29)	24 (26)	3 (5)	346 (19)	<0.01

^a KSA: Kingdom of Saudi Arabia; UAE: United Arab Emirates.

(God's) protection (40%) and MERS-CoV was not a fatal disease (29%), considering MERS-CoV to be a media propaganda (26%), and holding that they were not at risk of exposure to camels (5%). On the other hand, 33% of respondents were highly or moderately concerned about MERS-CoV (Table 3); the following reasons were given: having poor immunity (37%), reports of several cases in the same city or country (28%), infected cases among family members or friends (26%) and high risk occupation (e.g., being a HCW) (9%). Those with chronic conditions (OR: 1.7, 95% CI: 1.1–1.7, $p < 0.01$) were more likely to be concerned of contracting MERS-CoV, however, males (aOR: 0.6, 95% CI: 0.4–0.9, $p = 0.01$) and participants who thought MERS-CoV was serious only for individuals with high risk conditions were less likely to be concerned about the disease (aOR: 0.6, 95% CI: 0.4–0.8, $p = 0.01$).

Participants' knowledge and practices about MERS-CoV and its transmission

Human-to-human transmission

Majority (79%) of respondents rightly stated that MERS-CoV can transmit through droplet spread via sneezing or coughing from an infected person however, 21% reported that the disease transmits through direct contact with an infected person. Other respondents reported several other modes of transmission (e.g., through air, contaminated food and contaminated surfaces), however their awareness varied by country (Table 3). In multivariate analysis, males (aOR: 2.3, 95% CI: 1.4–4.2, $p < 0.01$), students (aOR: 4.1, 95% CI: 2.1–7.5, $p < 0.01$), individuals with postgraduate qualifications (aOR: 2.3, 95% CI: 1.2–4.3, $p = 0.01$), and residents of Saudi Arabia (aOR: 2.7, 95% CI: 1.7–4.2, $p < 0.01$) and Bahrain (aOR: 2.6, 95% CI: 1.3–5.3, $p < 0.01$) were more likely to have accurate knowledge of the human-to-human transmission of MERS-CoV.

Participants' compliance with protective measures is summarized in Table 3. The most commonly practised protective behavior was hand hygiene (e.g., hand washing with water or disinfectants), adopted by 40% to 50% of respondents (Table 4). Students (aOR: 2.9, 95% CI: 2.1–4.2, $p < 0.01$), government employees (aOR: 1.7, 95% CI: 1.2–2.5, $p < 0.01$), and residents of Saudi Arabia (aOR: 2.3, 95% CI: 1.8–3.1, $p < 0.01$) and Bahrain (aOR: 2.4, 95% CI: 1.5–3.9, $p < 0.01$) were more likely to comply with hand hygiene.

Overall, 39% of participants intended to avoid close contact with sick individuals who exhibited flu-like symptoms (e.g., coughing and sneezing) (Table 4). Those with an undergraduate qualification (aOR: 1.8, 95% CI: 1.4–2.2, $p < 0.01$), a postgraduate qualification (aOR: 3.2, 95% CI: 2.1–5.1, $p < 0.01$), and residents of Oman (aOR: 2.8, 95% CI: 1.5–5.2, $p < 0.01$), Saudi Arabia (aOR: 1.5, 95% CI: 1.1–2.1, $p < 0.01$) and Qatar (aOR: 2.1, 95% CI: 1.2–3.6, $p < 0.01$) were more likely to avoid close contact with sick individuals.

Regarding wearing facemask while visiting a sick person with flu-like symptoms, 40% reported practising it. Those with undergraduate degree (aOR: 1.4, 95% CI: 1.1–1.7, $p < 0.01$), government employee (aOR: 1.4, 95% CI: 1.1–1.9, $p < 0.01$), residents of Saudi Arabia (aOR: 2.1, 95% CI: 1.3–2.9, $p < 0.01$), Bahrain (aOR: 2.4, 95% CI: 1.3–4.1, $p < 0.01$), Kuwait (aOR: 1.7, 95% CI: 1.1–2.7, $p = 0.01$) and UAE (aOR: 1.6, 95% CI: 1.1–2.7, $p = 0.03$) were more likely to comply with this measure. Conversely, individuals aged over 37 years were less likely to use facemask while meeting a sick person compared to younger people (aOR: 0.6, 95% CI: 0.4–0.8, $p < 0.01$).

Wearing facemask in crowded public places was practised by 24% of respondents. Only those with postgraduate qualification were more likely to use facemask in crowded places than others (aOR: 2.8, 95% CI: 1.8–4.4, $p < 0.01$). However, males (aOR: 0.6, 95% CI: 0.5–0.9, $p = 0.01$) and those who were aged between 37 to 55 years (aOR: 0.3, 95% CI: 0.3–0.8, $p < 0.01$) were less likely to use facemask in crowded places.

Zoonotic transmission

Only 12% of respondents reported that MERS-CoV transmits through close contact with infected camels; those with postgraduate education (aOR: 1.8, 95% CI: 1.1–3.3, $p = 0.04$) were more likely to report that MERS-CoV transmits through camels, however, people in UAE (aOR: 0.4, 95% CI: 0.2–0.7, $p < 0.01$) and Kuwait (aOR: 0.5, 95% CI: 0.3–0.7, $p < 0.01$) were less likely to report so. Respondents also reported other modes of transmission, including consumption of raw camel milk (18%) and meat (62%), however their awareness varied by country (Table 3).

In addition, only 22% of respondents believed that camels are the zoonotic reservoir of MERS-CoV, whereas the remaining 78% did not believe or are unsure if camels were a reservoir (Table 3). Interestingly, of those who were aware that the disease can transmit through close contact with camels only 31% (65/209) believed that camels are the zoonotic reservoir of MERS-CoV. Those who were concerned about contracting MERS-CoV (aOR: 1.6, 95% CI: 1.2–2.1, $p < 0.01$) and those who thought MERS-CoV to be a severe disease only for those with high-risk conditions (aOR: 1.5, 95% CI: 1.1–2.1, $p < 0.01$) were more likely to believe that camels are the zoonotic source. However, residents of KSA (aOR: 0.03, 95% CI: 0.01–0.07, $p < 0.01$), UAE (aOR: 0.01, 95% CI: 0.004–0.02, $p < 0.01$) and Kuwait (aOR: 0.03, 95% CI: 0.01–0.07, $p < 0.01$) were less likely to believe that camels are the main zoonotic source compared to respondents from the other countries.

Participants' compliance to the protective measures is summarized in Table 4. Over half (57%) stated that they avoided close contact with camels during the study period (e.g., riding or photographing with camel, and visiting camel farms). Those who were aware that MERS-CoV can transmit through close contact with

camels (aOR: 1.3, 95% CI: 1.1–1.7, $p < 0.01$) and those who thought the disease to be severe for everyone (aOR: 1.5, 95% CI: 1.1–2.1, $p = 0.01$) were more likely to avoid camel contact. In contrast, males (aOR: 0.4, 95% CI: 0.3–0.6, $p < 0.01$), those with chronic medical conditions (aOR: 0.7, 95% CI: 0.5–0.9, $p = 0.01$), and residents of Saudi Arabia (aOR: 0.3, 95% CI: 0.2–0.5, $p < 0.01$) and UAE (aOR: 0.5, 95% CI: 0.3–0.9, $p < 0.01$) were less likely to avoid close contact with camels.

About a quarter of respondents intended to avoid consumption of raw camel products including milk (28%) and meat (22%). Residents of Oman (aOR: 1.8, 95% CI: 1.1–3.3, $p < 0.01$) and individuals who were generally concerned about MERS-CoV (aOR: 1.7, 95% CI: 1.4–2.2, $p < 0.01$) were more likely to avoid consumption of raw camel products.

Discussion

This is the first in-depth study involving participants from six Middle East countries showing that public perception and practices surrounding MERS-CoV vary widely among the public within these countries. There was a discrepancy between the respondents' perception about MERS-CoV and their actual compliance with preventive measures against it.

Overall participants' awareness about the MERS-CoV outbreak in the Middle East recorded in this survey is comparable to other surveys conducted among the general public in Saudi Arabia which showed that over 97% respondents were generally aware of MERS-CoV [8,16], but public awareness in this study was much higher than that among Hajj pilgrims to Saudi Arabia [17–20]. However, participants' specific knowledge about the mode of transmission was lower and differed depending on the modalities of transmission; for example, overall 79% participants knew that MERS-CoV transmits through coughing or sneezing (i.e., through large droplets) which is comparable to 72%–91% Saudi public knowing that coughing or sneezing spread MERS-CoV [8,9,16]. Conversely, this survey shows that only 21% of participants (24% of Saudi Arabian respondents) believed that MERS-CoV transmits through close contact with infected person, which is comparable to 31% Saudi citizens believing so, but much lower compared to another study which demonstrated that >70% Saudi people considered MERS-CoV to spread from person to person via close contact such as shaking hands with an infected person [8,9], but without sustained community transmission [8]; this difference may suggest that in-depth knowledge of MERS-CoV transmission is very much individual, and people build on learning about this from their background knowledge and life experiences. For example, surveys involving healthcare workers have shown that 64% of dental students and 88% of hospital HCWs were aware that MERS-CoV can transmit through close contact like caring for and/or living in the same house with infected persons, indicating that persons with better understanding of the disease were more aware of its transmission [10,11].

In this study we found that there is inter-country variability of public perception of MERS-CoV in GCC countries, for example participants from Oman reported more accurate knowledge about the infection and complied better with most preventive measures than the participants from the other countries. This inter-country variability of public perception of MERS-CoV in GCC countries resembles the transnational differences in adoption of preventive behaviors against H1N1 pandemic influenza in 2009 [21]. This variability could be related to an array of factors that affect behavior adoption, including the burden of disease, government mitigation plans, cost and availability of interventions, and the media's portrayal of the disease [21]; and the public's level of understanding may correspond with the degree of stringency imposed by health authorities [22].

Most participants (overall 40%) perceived MERS-CoV to be severe for all, but again there was inter-country variation: respondents from Saudi Arabia were about five times more likely to report so compared to respondents from other countries. Only 7% respondents thought it to be severe only for the elderly (adults aged ≥ 65 years). In contrast, a survey involving Saudi Arabian people demonstrated that 47.6% respondents believed the elderly people to be at special risk of MERS-CoV [8] and another Saudi Arabian survey showed that 80% respondents were not seriously worried about MERS-CoV [16]. In our study no participant from Bahrain and Qatar expressed significant concern presumably because of very low case burden in those countries.

An interesting relationship was observed when the nexus between public understanding about the transmission of MERS-CoV on exposure to camels or their raw products and people's beliefs about camels being a zoonotic source was considered against their practice around the avoidance of close camel contact or abstention from consumption of raw camel products. Only 12% respondents said that MERS-CoV can be acquired by coming in direct contact with infected camels yet 56% participants avoided camel contact. On the contrary, respectively 18% and 62% believed that it can be acquired by consuming raw milk and meat, yet only 22% respondents believed camels to be a zoonotic reservoir, and up to 28% participants avoided raw camel products. This observation remains difficult to explain fully, however other surveys involving Saudi public and trainee HCWs have shown that about 50% respondents believed camels to be the source of MERS-CoV [8,9,11]. From the example of avoiding camel contact, a unique observation was that there was an upward transition from peoples' awareness to action. This finding can be explained by 'precaution adoption process model' (Fig. 1). The framework of this model sets forward stages of health behavior change in an individual and the factors that lead people to move from one stage to another such as beliefs, perceived susceptibility, perceived severity, perceived barriers, motivation, and cues to action [23]. Paradoxically, however, more respondents (56%) avoided camels while only a small proportion (12%) was aware of the acquisition of MERS-CoV from camels. This is likely because, contact with camel or consumption of its raw products (milk, liver, meat, and urine) is associated with other exotic infections such as brucellosis, plague, and rift valley fever [24–26], so some respondents may have avoided exposure to camel to prevent other non-MERS diseases.

Results from this study also found hand hygiene ($\geq 44\%$) and cough etiquette (46%) to be more popular measures, while face-mask use in crowded places was less popular reported by only 24% of participants. Other surveys conducted in Saudi Arabia demonstrated that 74%–94% participants practised hand washing [9], and between 81% and 93% practised respiratory etiquette in order to protect from MERS-CoV [9]. The use of facemask varies widely: a recent survey conducted in Riyadh reported that 75% participants used facemask in crowded places while a country-wide survey demonstrated that 11% used facemasks in public places [8,9]. This is likely because hand hygiene and cough etiquette are easy to implement, culturally acceptable among Arabic people and complement Muslims' daily washing five times a day before prayers [27].

This study shows that being well-educated (e.g., having a university qualification), a government employee, or a resident of certain countries (e.g., Saudi Arabia) were significantly associated with better awareness of MERS-CoV, and higher compliance with preventive measures. Similarly, in another survey involving Saudi citizens, respondents who reported to be aware of MERS-CoV were more likely to have at least high school level education, but surprisingly more likely to be unemployed or employed in health care sector [16].

Interestingly, this study also revealed that most participants who had no or only slight concern regarding catching MERS-

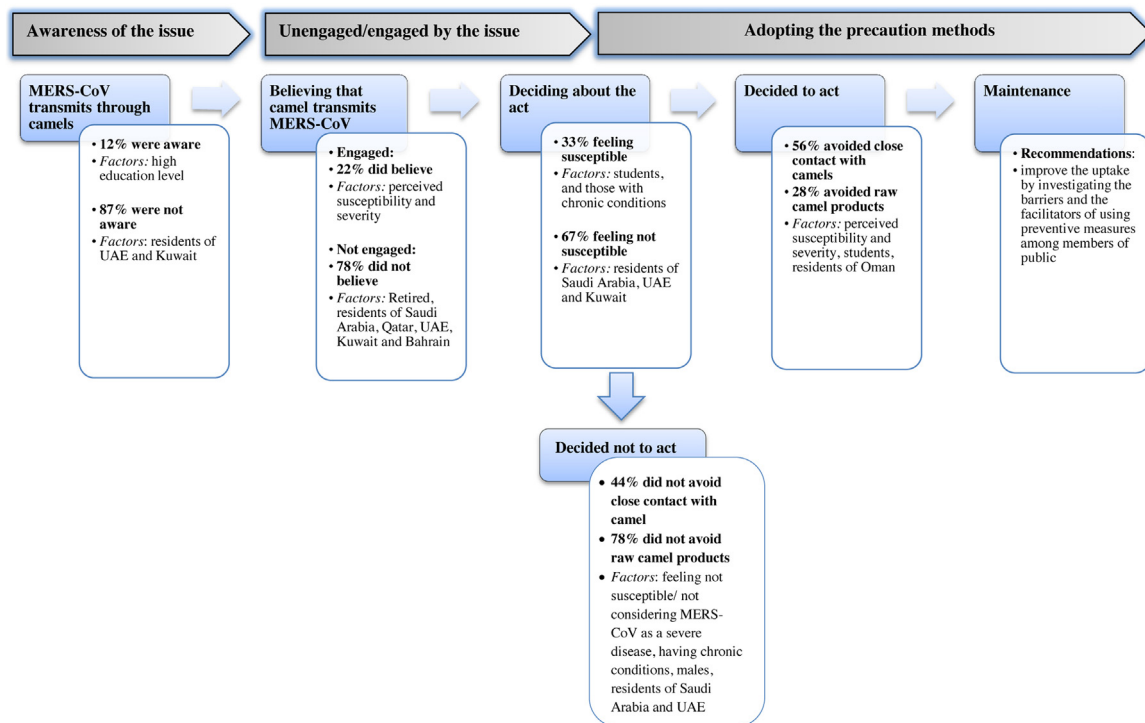


Fig. 1. Applied precaution adoption model on avoidance of camel contact in survey participants.

CoV implied that no major calamity will befall them so long as they remain under God's protection, some other participants had genuine misperception about MERS-CoV: about one third of respondents thought that MERS-CoV was not fatal, and over a quarter believed that it was a mere media propaganda. Other surveys involving Saudi public showed that faith in God was a strong resilience factor against serious emerging infectious threats, and a survey involving Australian Hajj pilgrims has shown that some people misinterpret this faith in God to such an extent that they use it as an excuse to miss out recommended vaccinations [28,29].

This study indicates that the use of smartphone applications to track the change in health behavior among public is feasible. Smartphones are increasingly becoming an essential part of modern life, for example in Saudi Arabia about 70% of mobile users own smartphones [30]. A few studies have demonstrated the usefulness of using electronic surveys, including by using mobile devices, in conducting surveys with promising results [31–34]. For instance, in a comparative study of pen and paper survey versus smart phone data collection, Zhang et al. [32] demonstrated that much data recording and entry errors were prevented in smart phone surveys (while in pen–paper based surveys 65% of the data did not match and needed to be rechecked subsequently). Our team have also successfully tested this method in tracking Hajj pilgrims' health behaviors in 2014 [35]. This study shows that using smartphones allows fast communication with target population, saves time and effort, and is cheap. However, using smartphones in social and epidemiological research works has not yet gained much popularity and deserves further evaluation to confirm its effectiveness.

This study demonstrates that despite being aware of MERS-CoV epidemic many individuals in GCC countries lack proper knowledge about its transmission and prevention, and not fully compliant with preventive measures. There are significant opportunities to improve public perception, and compliance with preventive health measures against MERS-CoV among people of GCC countries. To some extent, this could be achieved by supplying the public with up-to-date, culturally appropriate health information.

This study has some limitations. As a cross sectional study, no follow up was conducted, and public perception assessed at a point of time may not be representative of their consistent beliefs or practices, this is particularly true for their exposure to camels; second, the cohort was skewed toward male since 82% of the participants were male; third, the data were self-reported and the actual behaviors practised may be different; fourth, the number of participants from one country (Oman) was too low to allow sub-group analysis which might have biased the comparison; fifth, no question was asked about the respondents' urban or rural dwelling hence stratification of data based on rural and urban regions was not possible, sixth, the study may have excluded people with limited or no access to smartphones leading to potential selection bias, finally, although smartphone use is gradually becoming ubiquitous, as a survey tool it too introduces bias resulting from intrinsic factors related to its users. All these factors could limit the generalizability of findings. Despite these limitations this study has provided unique data on public perceptions and practices surrounding MERS-CoV.

To conclude, this study highlights that many people in GCC countries lack accurate understanding about MERS-CoV transmission, biology and prevention, and are not fully compliant with preventive measures. There is considerable variation between countries; people from countries with higher disease burden seem to be more aware of the disease.

Authors' contribution

A.S.A.: designed the study, analysed data and drafting the manuscript. N.F.B.: founded Gulf Indicators (GI) smartphone app project and revised all versions of the manuscript. H.R.: supervised data analysis and revised all versions of the manuscript. M.H.B. and T.M.A.: collected data and revised all versions of the manuscript. All the authors have substantial contribution in editing the manuscript.

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Competing interests

Author H.R. has received research grants from Pfizer and Novartis for consulting or serving on an advisory board. The other Authors (A.S.A., M.H.B., T.M.A. and N.F.B.) have declared no conflict of interest in relation to this work.

Ethical approval

This study was reviewed and approved by the Human Research Ethics Committee at King Saud University (Ethics Ref No: 4/2016), Riyadh, Saudi Arabia. Confidentiality of the respondents was assured by instructing them not to write their names or anything that would identify them in any part of the questionnaire. Participation was voluntary and electronic informed consent was obtained from all individual participants included in the study.

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