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Reduction of MERS-CoV Transmission among Healthcare Workers and Patients in Saudi Arabian Healthcare Settings: A Scoping Review (Thesis)

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Abstract— **Background: No review consolidating available evidence of the various interventions for preventing MERS-CoV transmission in healthcare settings has been published to inform practice. The MERS-CoV outbreak in Saudi Arabia led to wide-scale hospitalisations and, among other individuals at risk, healthcare workers (HCW) were one of the most affected groups. This study evaluates the effectiveness of various interventions implemented to prevent MERS-CoV transmission to HCW and MERS-negative patients in Saudi Arabian healthcare settings.**

Methods: This review summarises and evaluates the effectiveness of MERS-CoV infection prevention and control (IPC) measures in Saudi Arabian hospital settings. Instead of using 'best quality/evidence' studies, the review has included as many relevant studies as possible.

Results: Various IPC measures were deemed effective. However, since no analysis of their effectiveness had been undertaken, it was not possible to determine the interventions' level of effectiveness as applied in hospital settings. The studies appeared to rely on the assumption that the extent of MERS-CoV transmission control observed was a direct reflection of the implemented IPC measures.

Conclusions: Robust studies, using empirical methods, should be conducted to measure the effectiveness of the various IPC measures developed and implemented to control MERS-CoV transmission.

Index Terms—**MERS-CoV, outbreak, personal protective equipment, severe acute respiratory infection**

I. Introduction

Throughout the world, viral infections are spreading faster and becoming less controllable [1], and healthcare systems must be prepared to address unexpected emergencies during infectious disease outbreaks. This review explores the effectiveness of the MERS-CoV infection prevention and control (IPC) interventions implemented in Saudi Arabian hospitals.

The Middle East respiratory syndrome (MERS), a viral respiratory infection caused by a coronavirus (MERS-CoV), was first diagnosed in Saudi Arabia in 2012 [2-4]. Although asymptomatic carriage has been observed, MERS-CoV infection can result in potentially fatal acute respiratory disease [2]. MERS-CoV is closely related to SARS-CoV (severe acute respiratory syndrome coronavirus), and the infection may be associated with acute hypoxaemic respiratory failure and multi-organ failure requiring Intensive Care Unit (ICU) admission [5].

The World Health Organization (WHO) estimated that, as of September 27, 2016, there were 1,806 MERS-CoV cases, including 643 deaths related to

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the disease [5]. Saudi Arabia accounted for approximately 80% of the MERS cases [3]; of those, approximately 45% infections occurred in hospitals or other healthcare facilities [5,6]. A possible cause of this high infection rate was unprotected care of MERS-CoV patients and a general failure of the healthcare system to implement control measures [7].

MERS-CoV is transmitted through respiratory droplets and mostly in nosocomial settings; as such, healthcare workers (HCW) in contact with MERS-positive patients are at high risk of infection [8]; other individuals at risk include patients without MERS who are hospitalised in wards treating MERS-CoV-infected patients. For instance, during the 2013 Al Hasa outbreak in Saudi Arabia, seven patients in the ICU and dialysis units were infected by one MERS-CoV-infected patient who shared the facility with them. Poor ventilation and overcrowding of the emergency department (ED) were also cited among the major factors contributing to healthcare-associated transmission and outbreaks [1,9-11].

Efforts to understand the aetiology of MERS and to map its transmission continue. Data from the MERS-CoV outbreaks highlighted the need to evaluate current infection control standards and practices and compliance with infection control standards in Saudi hospital settings. These standards included basic practices, such as personal protective equipment (PPE) and hand hygiene, as well as other interventions that address triage, flow, placement [12], and handling of patients within healthcare facilities. Other prevention measures include HCW training, patient isolation, patient/clinical triage, contact tracing, surveillance/monitoring of suspected MERS cases, visitor restrictions, suspension of elective surgeries, distribution of IPC guidelines, use of an Infectious Disease Epidemic Plan (IDEP), establishment of a control centre, ED closure, equipment and environmental cleanliness, having an ED contingency plan, and rapid response team visits.

Infection control guidelines designed to prevent the transmission of MERS-CoV were in place; however, they were developed mostly based on the experience of controlling a similar virus, namely severe acute respiratory syndrome coronavirus (SARS-CoV) [13].

The present review is particularly important as we did not find any study undertaken to provide healthcare professionals and health service managers with an overview of measures implemented to control MERS-CoV in Saudi Arabia's healthcare facilities. Therefore, this scoping review aims to summarise the available evidence regarding the effectiveness of measures to prevent MERS-CoV transmission in Saudi Arabian hospital settings. The review adheres to the methodological framework for conducting scoping reviews, according to Arksey and O'Malley (2005), which consists of five stages: 1) identifying the research question, 2) finding related studies, 3) study selection, 4) charting the data, and 5) collecting, making summaries, and reporting results [14].

A. Research Question

What measures have been identified in the scientific literature that effectively reduce the transmission of MERS-CoV to HCW and MERS-negative patients in Saudi Arabian healthcare settings?

B. Research Objective

The aim of this study was to summarise and evaluate available data on the effectiveness of MERS-CoV IPC measures in Saudi Arabian hospital settings.

C. Definition of Key Terms

To better understand the research question and the parameters of this review, it is important to define and clarify some of the terms used in the research question. 'Healthcare workers', as used in the research question, is a broad term referring to all those working in healthcare settings. However, for the purpose of this review, the term will be used to refer to those directly in contact with and involved in providing healthcare to MERS-CoV patients in healthcare settings, including nurses, doctors, those involved in specimen sampling from patients for laboratory testing, and those otherwise involved in patient management. The term 'patients', as used in the research question, refers to MERS-negative patients who are hospitalised alongside MERS-positive patients and share the same healthcare

facility and services. Lastly, the term 'healthcare settings' refers to hospitals to which MERS-CoV patients have been admitted.

II. Methods

This section describes the literature search to identify empirical studies relevant to answering the research question. There is no definitive way to undertake a scoping study, although its main purpose is to identify existing literature rather than address the quality of individual studies [15]. As such, this review sought to be as comprehensive as possible. Indeed, Arksey and O'Malley (2005) observed that the scoping field's purpose is to identify studies and reviews relevant to answering the research question comprehensively [14].

A. Identifying Relevant Studies

Relevant study identification begins with the search for studies through different sources, including electronic databases, relevant organisations, manual searching in key journals, and reference lists [14]. For the present scoping review, relevant study identification was limited to searching electronic databases, websites of relevant organisations, and the reference lists of relevant research articles.

1) Electronic Search: The specific electronic journal databases searched included PubMed, BioMed Central, ScienceDirect, Sage, and Taylor & Francis Online. For this scoping review, research studies undertaken in the last five years (2017- 2021) were considered for inclusion because the first MERS case was identified in Saudi Arabia in 2012 [16]. Studies not written in English were not considered for inclusion because of the time and cost of translation. Organisations whose websites were searched included Centers for Disease Control and Prevention (CDC), World Health Organization (WHO), and Saudi Arabia's Ministry of Health. The following key terms and search terms (and any relevant alternative terms) were used in isolation and/or in combination to perform the electronic search and identify relevant studies; the search terms were developed from the research question.

Key Terms and Search Terms:

- MERS-CoV
- MERS-CoV transmission prevention
- MERS-CoV Saudi Arabia
- Healthcare workers/patients
- Infectious Disease Epidemic Plan
- MERS-CoV infection control measures
- Patient isolation
- Hand hygiene
- Personal protective equipment
- Infection prevention and control
- Saudi Arabia
- Outbreak
- Response/management
- Severe acute respiratory infection
- Middle East respiratory syndrome
- Critical care
- Disease outbreak
- Disaster planning

The search strategy was developed to maximise the number of relevant studies obtained for inclusion, while minimising the number of irrelevant studies. Appendix 1 describes the search process, including the search terms used, the total number of articles produced by the search, and the number of relevant studies retrieved.

2) Reference Checking: Apart from searching electronic databases and websites of key organisations, reference lists of relevant studies obtained from the electronic search were checked for related studies to be included in the review. This was important to limit the risk of omitting relevant studies, thereby ensuring that the literature search was as comprehensive as possible. This process led to the generation of additional data sources.

B. Outcome Measures

The outcome measures for this review included prevention of transmission, control of transmission, or reduction of transmission of MERS-CoV in hospital settings (as a result of implemented IPC measures); these were critical to determining whether specific infection control measures implemented in each hospital setting were effective in preventing or reducing MERS-CoV transmission.

C. Study Selection

The search strategy produced a large number of irrelevant studies. The inclusion/exclusion criteria, outlined below, enabled the researcher to exclude a

vast number of irrelevant studies. All studies meeting the below-listed inclusion criteria were included in the review, regardless of methodology.

1) Inclusion and Exclusion Criteria: The inclusion/exclusion criteria for this study were developed ad hoc to facilitate the identification of studies to include in the review [17]. Generally, the criteria for inclusion were studies carried out in healthcare/hospital settings, studies that addressed MERS-CoV transmission, and studies addressing MERS-CoV transmission control.

Although the main focus of this review was the control of transmission of MERS-CoV in Saudi Arabia's healthcare settings, the studies selected for review were not limited to Saudi Arabia. There were two reasons for this: one was to allow for the inclusion of as many studies as possible in case there were few relevant studies performed in Saudi Arabia. The second reason was the assumption that control measures applied elsewhere could also be applied in Saudi Arabia; as such, the study locations were irrelevant. The following inclusion and exclusion criteria were developed ad hoc and informed by the research question.

Inclusion Criteria:

- Studies addressing infection control/transmission of MERS-CoV
- Studies conducted in healthcare/hospitals settings
- Studies whose target population (participants) was HCW and MERS-negative patients who are at risk
- Reports authored by government departments (public health authority) and both local and international non-governmental organisations such as the World Health Organization
- Other studies

Exclusion Criteria:

- Editorials
- Commentaries/opinions
- Studies not addressing MERS-CoV infection control/transmission
- Studies conducted outside hospital/healthcare settings
- Studies not targeting HCW and patients

III. Results

The search strategy returned 3,211 articles (Figure 1). Many of them were duplicates, the removal of which left 1,632 articles for review. The titles and abstracts of the remaining articles were screened according to the above inclusion/exclusion criteria. 1,601 articles were subsequently excluded as they did not meet the inclusion criteria. Full-text versions of the remaining 30 articles were retrieved to further assess whether they fully met the inclusion criteria. This led to the exclusion of a further 20 articles; nine because they were not empirical studies, eight because they did not address the outcome measures, and three because the studies were not conducted in hospital settings. Table 1. lists the number of studies identified through each bibliographic source.

A. Charting the Data

Data were extracted from all 10 studies selected for inclusion. The following information was extracted from the studies: title of the study, name of the author(s) and year of publication, target population and country, study objective, research methods employed, ICP interventions used and for how long, and outcomes (Table 2). Table 3 lists the appraisal of the evidence presented in the various studies.

B. Collating, Summarising, and Reporting the Results

This section maps the distribution, nature, and extent of the studies incorporated in the review, in terms of the intervention group, range of interventions, research methods, outcome measures, and comparison of control outcomes for HCW and patients.

1) Distribution of Studies According to Intervention Group: Studies were categorised according to the care group being targeted by interventions to control MERS-CoV transmission. Studies were subsequently categorised into three categories: those targeting both HCW and patients; those targeting HCW only; and those targeting patients only. The majority (50%) of the studies targeted both HCW and patients. Forty percent targeted HCW, while the remainder of the studies (10%) targeted patients

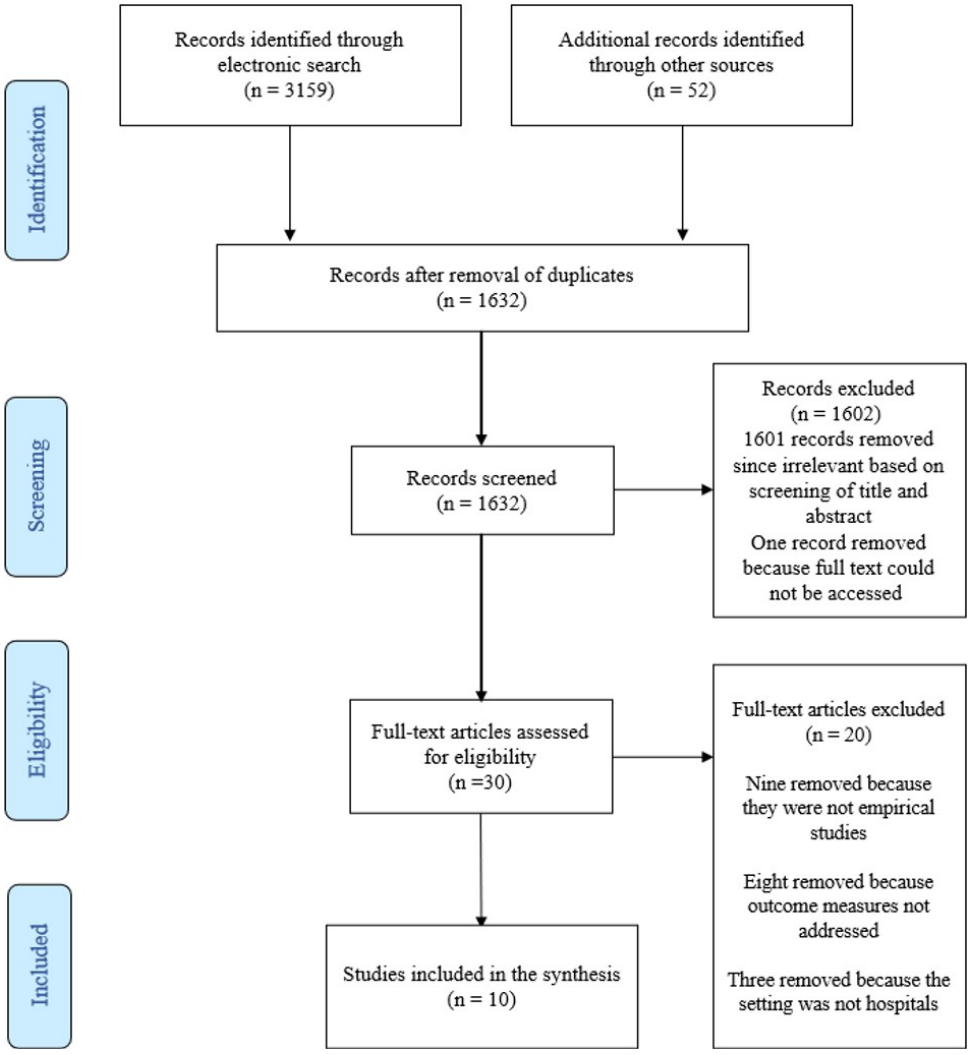

Figure. 1. PRISMA Flow Chart

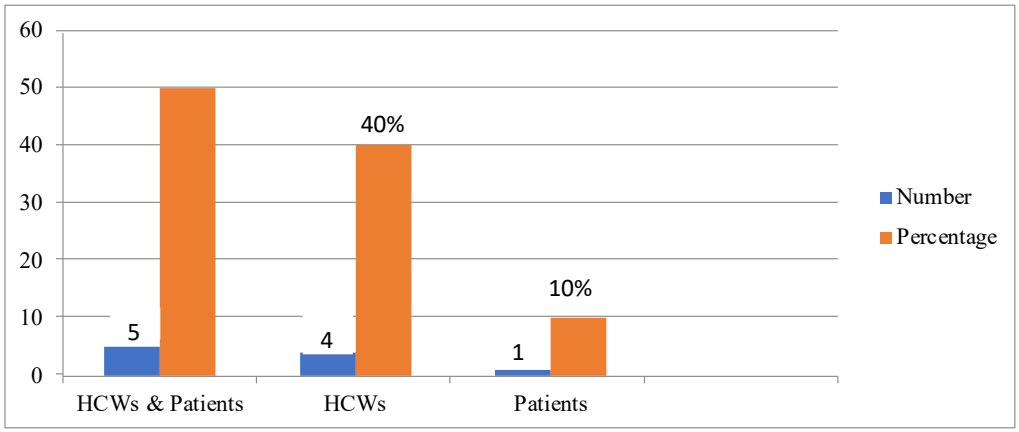

Figure 2. Proportion and Number of Studies Targeting Different Care Groups

only. Figure 2 shows the proportion and number of studies targeting the above three groups.

Evaluation Based on Level of Effectiveness:

Interventions targeting both patients and HCW were three times more effective than those targeting only patients or only HCW. The combination of the two sets of measures yielded better results than those applied to patients or HCW only, because the infection was being tackled from two fronts. Infected patients can pass the infection to HCW and vice versa [1]. Therefore, if only patients are targeted, then HCW who may be infected via contact with patients upon arrival will still spread the virus. Addressing the needs of both groups simultaneously helped, because none could pass infection to others.

Targeting Different Care Groups

2) Range of IPC Interventions: Several types of IPC interventions have been developed to stop MERS-CoV transmission in hospitals. The below categorisation of interventions (basic, administrative, and environmental) was adapted from WHO guidelines for the control of MERS-CoV infection transmission [25].

The most common IPC measures were the following (in hierarchical order):

Types of Interventions Identified in This Review (Table 4)

Basic Interventions

These include:

- Hand hygiene
- Patient isolation (in standard rooms and in negative pressure rooms)
- Face masks
- Eye protection
- Gloves
- Gowns
- N95 respirators

As seen, no studies applied any basic intervention in isolation; they all combined more than one intervention. There were overlaps, with different studies combining different interventions interchangeably.

Administrative Interventions

These interventions also include administrative controls such as (Table 5):

- An Infectious Disease Epidemic Plan (IDEP)
- Clinical/patient triage
- Contact tracing
- Surveillance/monitoring
- Suspension of elective surgeries
- Education/training of HCW
- Control/restriction of visitors
- IPC guidelines
- Suspension of outpatient services
- Visits by a rapid response team
- Establishment of a command control centre
- Having an ED contingency plan

Healthcare System Interventions

Healthcare interventions included measures such as (Table 6):

- Taking nasopharyngeal swabs
- Isolating MERS patients in negative pressure rooms
- Maintaining environmental and equipment hygiene
- Closing the ED

In summary, all studies included in this review applied a combination of IPC interventions, with much overlap between studies in terms of interventions used. PPE-associated interventions were used in 90% of the studies, followed by MERS patient isolation in 80% of the studies (30% involving isolation in negative pressure rooms, and 50% in standard rooms). The third-most commonly used intervention was hand hygiene, which was applied in 50% of the studies. All studies included at least one basic IPC intervention in their investigations, making this category of intervention the most common. Most of the moderately used interventions fell into the category of administrative control measures, with education/training of HCW applied in 40% of the studies, clinical triage in 30% of the studies, as well as contact tracing and patient surveillance/monitoring. The least used interventions included suspension of outpatient services, which was applied in 10% of the studies; establishment of a command centre; and visits by a rapid response team.

Research Methods and Outcome Measures (Quality of Evidence: From the studies included in the review (n = 10), five (50%) adopted a descriptive design; another four (40%) used an observational design (essentially descriptive in nature); and the remaining study was a report (refer to the Joanna

Brigs critical appraisal checklist above). According to a system ranking the strength of evidence on the basis of study design, descriptive studies and reports have the lowest evidence strength [26]. Therefore, the strength of evidence of all the studies included in the review can be regarded as low. The evidence provided cannot be generalised to the rest of the population. Moreover, except for one study that which was conducted across 31 hospitals affected by MERS, all the other studies were single-centre studies.

Various outcomes were achieved by the IPC interventions implemented in the studies, including a 60% reduction of MERS-CoV transmission (in 50% of the studies); prevention of MERS-CoV transmission (in 30% of the studies); control of MERS-CoV transmission (in 10% of the studies); and a combination of reduction and prevention outcomes (in 10% of the studies).

No tools or methods were used to measure the interventions' effectiveness in achieving these outcomes. As such, it was assumed that any reduction, control, or lack of transmission was associated with interventions. This assumption contributes to the weakness of the presented evidence regarding the effectiveness of infection control interventions, since the possible effects of other confounding factors were not considered. No studies evaluated the effectiveness of the applied interventions, but most of them provided descriptions. In order to evaluate any intervention, researchers should be able to measure how effective the intervention is by studying each intervention in isolation to understand its individual contribution to the control and prevention of the disease. However, this could prove a difficult task given that, in practice, many interventions are applied in combination in order to control a disease.

3) Comparison of Control Outcomes for HCW and Patients: From the analysis of outcomes for HCW vs. for patients, it emerged that HCW had better MERS-CoV control and reduction outcomes compared with those for patients. In one study, for instance, only two nurses (out of 196) and one physician (out of 80) working in MERS ICU units acquired MERS-CoV, and none of them died from the virus. Of the 63 patients admitted to the ICU due to the hospital outbreak, only eight were HCW. The mortality rate of the ICU patients was 63.4%, and none of those who died was a HCW [5]. In yet another study, 53 patients acquired MERS- CoV compared with 16 HCW [21]. The lower numbers of HCW acquiring MERS-CoV compared with patients is an interesting phenomenon that will be discussed further in the section below.

IV. Discussion

The four-level model of healthcare quality improvement, outlined by Ferlie and Shortell (2001), focuses on the individual patient, the care team, the organisation, and the political environment [27, 28]. This model was designed specifically to help improve the quality of healthcare delivered to patients. Quality improvement requires ongoing efforts to arrive at stable process results with no variations and to enhance these process results for the healthcare organisation and its users. The model is useful for helping to meet such needs. The organisation comprises a healthcare facility, such as a hospital, nursing home, or clinic, which supports the care team's development and activities by providing complementary infrastructure and resources. Finally, the economic and political environment, which includes payments, financial and regulatory regimes, and markets, makes up the conditions under which care teams, individual healthcare workers, organisations, and individual patients conduct their activities.

This review revealed that various interventions were used successfully to control, prevent, or reduce transmission of MERS-CoV to patients and/or HCW in healthcare settings. Although some of these interventions were implemented in South Korea and Thailand rather than in Saudi Arabia, they would still be applicable for reduction of transmission of MERS-CoV in Saudi Arabia's healthcare settings. Available guidelines informed the IPC measures for control and prevention of MERS-CoV transmission in healthcare settings, including guidelines from WHO (2015), CDC (2015), and Saudi Arabia's Ministry of Health (2015) [25, 29, 30]. With regard to the abovementioned four-level model of healthcare, most of the IPC interventions were implemented at the patient and care team levels.

A. IPC Measures Implemented at the Individual Patient Level

Patient-level IPC interventions were particularly effective in controlling MERS-CoV transmission. This effectiveness may be explained by the fact that the measures were applied directly to the affected patient. For example, isolation can easily stop the spread of the virus because the interaction between the affected patient and other people is strictly restricted [23]. Thus, the risk of contracting a viral infection from this particular person becomes negligible. Patient triage gives urgency to treatment, thereby solving the problem before it gets out of hand. Direct, patient-level control interventions have great potential for preventing and controlling MERS.

B. IPC Measures Implemented at the Healthcare Worker Level

At the HCW level, various interventions also appeared effective, because caregivers interact with patients more than anyone else. When caregivers are well protected, the risk of the virus spreading from patient to HCW is low; hence, it remains contained. Measures such as eye protection and face masks help keep HCW safe as they attend to infected individuals [22]. Having caregivers use PPE is a very effective way of controlling the spread of MERS at the HCW level.

C. IPC Measures Implemented at the Organisational Level

Organisation-level measures were not as effective as the aforementioned measures. Their lower success rate could be because such measures are not applied directly to the patient or the caregiver. Measures such as visitor restrictions, elective surgery suspension, distribution of IPC guidelines, IDEP use, establishment of a control centre, ED closure, equipment and environmental cleanliness, and having an ED contingency plan are important. However, some of these are not immediately implementable, thus leaving room for the virus to spread. Some measures at this level are also not easy to execute, since they require the allocation of time, planning, and resources, which may not be available within the time frame to prevent the infection from spreading [31]. Interventions at this level are not very effective; therefore, they should be applied when measures at the first two levels are already in place.

D. IPC Measures Implemented at the Political Level

At the political level, a rapid response team visited a hospital in one of the studies to ensure compliance with the Ministry of Health's (MOH) IPC guidelines [18]. Additionally, these guidelines were important for providing a standardised approach to the prevention of MERS-CoV transmission in hospitals. However, in the studies carried out in Saudi Arabia, none of the examined hospitals implemented the MOH's IPC guidelines in full. This was also the case with studies conducted in South Korea and Thailand, which did not fully implement their respective countries' IPC guidelines or those provided by WHO. Poor adherence to IPC guidelines has indeed been cited as among the major contributing factors to MERS-CoV transmission in healthcare settings [13].

Failure to implement guidelines, either in part or in full, may often be due to factors such as a shortage of trained health manpower to effectively implement the guidelines. Poor administrative and managerial skills in health facilities are also to blame for this situation. Furthermore, HCW may have failed to implement these guidelines due to the urgent need to control MERS-CoV and the feeling that following guidelines might slow down their efforts.

It is possible that better infection control outcomes could have been achieved if the IPC guidelines had been fully implemented in each of the examined hospitals. As such, hospitals in Saudi Arabia should consider fully implementing the interventions contained in the IPC guidelines, not only to achieve a standardised approach to infection control, but also to achieve better outcomes. As seen from the results, most of the studies used PPE; although this is the most used and most popular control intervention, it is the weakest and the last in a hierarchy of IPC interventions [25]. As such, it should not be relied upon as the main prevention strategy. Without other control measures (such as administrative control measures), PPE is of limited benefit [25]. In line with this, although PPE was the most commonly used intervention, most of the hospitals in the studies used PPE in combination with other control measures.

However, infection controls at the organisational level need to be used more to provide a robust control framework for the prevention of MERS-CoV. These should be supported by infection control at the political level, including the establishment of a robust surveillance system to monitor the strict implementation of IPC guidelines in hospitals. Although Saudi Arabia has a national surveillance system, in which all hospitals are required to enrol and report infectious agents according to the MOH guidelines, its implementation remains thus far unsuccessful, considering the fact that healthcare staff members across several hospitals were uncertain as to whether their hospitals were enrolled in the system [32]. Poor implementation has been blamed on inadequate resources allocated to public health facilities, lack of adequate training to ensure proper qualification and competence of healthcare providers, and an indifferent attitude in hospital staff with regard to adhering to guidelines [28]. There have also been examples of ineffective coordination of healthcare systems in various regions and towns, as well as across the entire Kingdom of Saudi Arabia.

E. Effectiveness of Interventions According to Target Group

It appeared that IPC interventions tended to work better for HCW than for patients. Fewer HCW acquired MERS-CoV infection, and none of them died from the infection despite their prolonged and close contact with MERS patients. The low infection rate among HCW might be due to better awareness, knowledge, and infection-specific education, and stricter adherence than patients to infection control measures. More intensive ascertainment among HCW by being subjected to mass screenings that allowed for early detection of cases that could have been missed. Thus, leading to the immediate practice of IPC measures such as isolation of confirmed or suspected cases to prevent further spread of the infection [6]. Additionally, lower transmission among HCW may be due to the possibility that, out of fear, they were careful about the outbreak [3, 28, 31, 33] and, therefore, closely monitored their symptoms and sought help before testing positive [12]; or detected the disease early and instigated the necessary control measures.

The lack of deaths among HCW might reflect this group's increased awareness about MERS symptoms and their constant monitoring of such symptoms, facilitating early detection and treatment. Awareness of the MERS-CoV case definition is indeed important for enabling early detection [17]. Apart from early diagnosis, the lack of deaths among HCW might also be explained by the better health and younger age of HCW [6]. Research evidence indeed indicates that MERS patients who are not HCW are significantly older than HCW [34, 35], and older age was found to be a risk factor for adverse outcomes among MERS cases [34]. Mitigating the risk factors of age (both young and old) is necessary, and can be done through close monitoring upon arrival at the hospital, as well as conducting awareness exercises that target people in these population brackets during potential outbreaks. Education on how to avoid and manage infections is also important, and such individuals should be given information on all the available ways of keeping safe, avoiding contacts, and seeking medical assistance in case of symptoms. Comorbidity among non-HCW patients was also found to be a risk factor for adverse outcomes as compared with HCW [34]. Co-morbid conditions leave non-HCW more vulnerable to MERS, and these risk factors must also be reduced or eliminated. Co-morbidity risk factors could be reduced through interventions such as public health vaccination strategies and awareness and public education campaigns. Patients should also be screened and treated for any other disease before receiving treatment for MERS-CoV.

To prevent MERS transmission between HCW and patients, the improvement of healthcare quality (in line with the four-level model) should include efforts directed towards preventing transmission to patients. Early identification and diagnosis of MERS patients is key to controlling the spread of MERS-CoV to other patients. To ensure early detection and, consequently, better patient outcomes, effective triage should be undertaken upon hospital admission, with subsequent quarantine of patients with respiratory tract infections [7]. A study found that visual triage was effective in the early identification of MERS-CoV cases [36]. Another study revealed

that early identification of a MERS-CoV patient ensured a zero-transmission level of MERS-CoV in the healthcare facility involved [20]. Early identification is important because it allows for suspected or confirmed MERS cases to be subjected to IPC measures, such as contact and airborne isolation, before coming into contact with other patients (and unsuspecting HCW).

From an organisational point of view, although the hospitals investigated in the studies implemented IPC measures to control a MERS outbreak, it appears that most of the hospitals evaluated were caught unaware and unprepared for the outbreak. Only one hospital had an IDEP, while another one had an ED contingency plan [1,5]. For better response to and control of hospital outbreaks of infectious diseases, such as MERS-CoV, all hospitals should have response plans, exercises, and training modules well in advance as part of their preparedness [37]. Once the outbreak strikes, the response plan should be implemented to address the disaster effects and mitigate the impact on the population [37]. The infectious disease disaster plan should include elements specific to a particular disease, depending on the pathogen's characteristics, its transmission, and mitigation measures [12]. For novel contagious infections, such as the MERS-CoV virus, standard infectious disease control measures can be used until measures for the novel disease have been developed. However, based on the studies reviewed here, the performance of standard measures falls below that of other measures specifically developed for MERS-CoV. With time, there is always a need for standards that can address specific issues. Saudi Arabia did not have national infection prevention and control guidelines in place before the MERS-CoV outbreak, a situation that left hospitals to develop individual guidelines. Thus, various hospitals came up with their own guidelines for infection control, and the studies indicate that not all hospitals applied the same infection control methods. However, the Minister of Health later formed a Scientific Advisory Council, which revised previous World Health Organization (WHO) and Centers for Disease Control and Prevention (CDC) guidelines and developed a revised version for use when caring for patients with suspected or possible MERS-CoV infection.

From the data extraction table (Table 2) it is clear that, in most of the studies (90%), using PPE such as masks, gloves, and gowns is among the most essential and effective interventions for controlling MERS. Most studies have cited PPE as being among the first interventions to apply in case of an outbreak. Other interventions, such as isolation, triage, and quarantine, were found to be very effective in curbing viral transmission; therefore, they join the list of essential measures. Some interventions may not be very effective in controlling an outbreak, but are necessary for long-term disease management. These fall under the non-essential but useful measures. In some of the studies, this category contains interventions such as having security measures in place to control patients, continued vigilance, administrative controls, and workplace safety, among others.

V. Limitations

This study has a number of limitations. The evidence presented here should be applied with caution, considering that none of the included studies measured the effectiveness of the IPC interventions implemented to control MERS-CoV transmission. Hence, the relative effectiveness of specific interventions could not be identified. The studies were largely descriptive and based on the assumption that the level of MERS-CoV transmission control observed was a direct reflection of the IPC measures applied. For more useful results, future studies should include evaluations of current practices and interventions.

Another limitation of this study is that it focused mainly on presenting a summary of the available evidence regarding the effectiveness of IPC interventions for controlling the spread of MERS-CoV, rather than an in-depth analysis of the quality of available evidence, as would be the case in a systematic review. As such, the evidence presented is inadequate for hospital and policy decision-making. Additionally, most of the studies were single-centre, so their findings cannot necessarily be generalised. Nonetheless, the evidence presented provides some insight into what could work for the control of this and potentially other respiratory viruses in Saudi Arabia.

VI. Conclusion

This review found that IPC interventions implemented at patient and HCW level, organisation level, and political level, across various hospital settings, were considered crucial in preventing, controlling, and/or reducing the transmission of MERS-CoV. Although PPE and hand hygiene were the most commonly used interventions, these are of limited effectiveness if not used in conjunction with administrative control measures.

A. Recommendation

Considering the above, PPE, hand hygiene, and other basic infection control measures should be used within a larger framework of organisational and political control. Additionally, as is evident from most studies, hospitals should implement these controls in full, rather than piecemeal, for more effective control. To limit transmission between HCW and patients, it is important to promote early detection through triage and surveillance, and to subject suspected and confirmed cases to the relevant controls, such as isolation. It is also important for hospitals to be prepared for MERS-CoV-like outbreaks by developing response plans to be followed when disaster strikes. Although the infection control measures applied in the included studies were considered effective in controlling MERS-CoV transmission, the presented evidence should be interpreted with caution since these were single-centre studies, mostly descriptive, and did not measure the effectiveness of the implemented interventions. Therefore, it was impossible to determine the level of effectiveness of specific MERS-CoV infection control interventions.

B. Future Outlook

In the future, more robust studies, using empirical methods, should be adopted to measure the effectiveness of the various IPC measures in controlling the transmission of MERS-CoV. Researchers should also focus on multi-centre studies to investigate the effectiveness of the various in preventing and controlling of MERS-CoV. Multi-centre trials typically produce more generalisable data, since they reflect a wider range of geographical locations, include a larger number of participants, may include a broader range of population groups, and can afford researchers the ability to make comparisons between different centres.

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Table 1. Number of Studies Identified According to Bibliographic Source (N = 3211)

Bibliographic Sources	**N**	**%**
PubMed	272	8.47
ScienceDirect	1,848	57.55
BioMed Central	330	10.28
Taylor & Francis Online	70	2.18
Sage	87	2.71
CDC	460	14.32
WHO	3	0.09
Ministry of Health	90	2.80
Reference checking	52	1.62

Table 2. Data Extraction Table

Title	Author(s) & Year	Population & Geographical setting	Study Objective	Research Methods	IPC Intervention & Period	Outcomes
The critical care response to a hospital outbreak of Middle East respiratory syndrome coronavirus (MERS-CoV) infection: an observational study	Al-Dorzi et al. (2016)[5]	Healthcare workers (HCW) (n = 8) and patients (n = 55). Study conducted in a hospital (King Abdulaziz Medical City) setting in Saudi Arabia following MERS outbreak in the hospital.	To describe how the ICU department at King Abdulaziz Medical City responded to the MERS outbreak that occurred in the hospital, the impact on its HCW, and the related changes in the hospital's workflow.	Observational study employing both qualitative and quantitative methods.	Study period was approx. three months (July 1 to October 21, 2015). There was a 19-month intervention period. *Essential effective measures:* ● Activation of Infectious Disease Epidemic Plan (IDEP) ● Closure of ED ● Cancellation of elective surgeries ● Suspension of outpatient clinic ● Establishment of a command centre and MERS unit ● Restriction of family visits ● Isolation of patients ● Training of ICU staff on the use of PPE	Although ICU staff was significantly exposed to the risk of acquiring MERS-CoV, only a small number actually acquired the infection. For example, two nurses (out of 196) and one physician (out of 80) working in MERS ICU units acquired MERS-CoV. *Essential effective measures:* ● Hand hygiene ● Imparting of knowledge to HCW about MERS infection ● Proper and early diagnosis of the virus ● Early and effective diagnosis and treatment of the virus in HCW. Non-HCW may not have such timely

		● Sufficient supply of PPE ● Saudi Ministry of Health & WHO guidelines for management of MERS given to ICU staff	diagnosis, thus allowing the spread of MERS-CoV amongst them. ● Early diagnosis and treatment of HCW can also be cited as the reason there were no HCW deaths reported, despite the virus's 63% mortality rate.
	Mean age of patients who acquired MERS was 57.9 ± 18.6 years; most of them male (69.8%).	*Non-essential but useful measures:* ● Implementation of airborne precautions for MERS cases ● Fit testing staff for N95 respirators ● Development and updating of specific policies for doffing and donning personal protective equipment (PPE) ● Provision of visual instructions in ICU rooms ● Setup of carts with PPE outside patients' rooms with PPE for	*Non-essential useful measures:* Creation of a multidisciplinary team using a multifaceted approach

					proper sequential donning ● More training in hand hygiene and use of PPE for HCW and housekeepers Collaboration between intensive care department and the infection prevention and control department	
Outcome of strict implementation of infection prevention control measures during an outbreak of Middle East respiratory syndrome	El Bushra et al. (2017)18	HCW and inpatients without MERS (n = 1,310). Study conducted in a hospital in Saudi Arabia following an outbreak in the hospital.	To demonstrate the outcome of infection prevention and control (IPC) interventions implemented during the MERS outbreak.	Observational study	*The interventions were conducted for approx. two months.* *Essential effective measures:* ● *Taking nasopharyngeal swabs inside the rooms that are lacking negative pressure* ● *Training on proper PPE use, proper hand hygiene, and IPC measures* ● *Conducting drills* ● *Implementing a standardised checklist for patient triage*	*In phase I, six primary cases led to 48 secondary cases. In phase II, secondary cases fell sharply to 18, while in phase III, secondary cases fell further to just one. The outcome indicates a pattern of reduction in infection, from 18 cases in phase II to one case in phase III (a difference of 17 cases). This reduction may be attributed to the tightening of the IPC measures.* *Essential effective measures:* ● *Increased awareness of the importance of*

					● *Cancelling elective surgeries; closure of ER* ● *Separating patients* ● *Controlling movement of patients and their escorts* *Non-essential but useful measures:* ● *Visual alerts posted about proper hand hygiene and cough etiquette* *Visit by rapid response team (RRT) to assess adherence to IPC measures*	*triaging and isolating patients who might have MERS infection* ● *Early detection through screening* ● *Adherence to standard IPC procedures and protocols* ● *Use of PPE* *Non-essential but useful measures:* ● *Training in, and evaluation of, infection prevention and control* *Having security personnel to control patients.*
Infection control and prevention practices implemented to reduce transmission risk of Middle East respiratory syndrome-corona virus in a tertiary care institution in Saudi Arabia	Butt et al. (2016)1	Healthcare workers (n = 180); non-healthcare workers (n = 694). Participants' gender and mean age not provided. Study conducted in Saudi Arabia.	To examine the effectiveness of a combination of B-IC and A-IC in prevention of MERS-CoV transmission.	Retrospective observational study. Participant data retrieved retrospectively from integrated clinical information system (ICIS).	*19-month intervention period.* *Essential effective measures:* ● *Basic infection control (B-IC) strategies* ● *Advanced infection control (A-IC) strategies* *Non-essential but useful measures:*	*Only 16 cases tested positive for MERS-CoV, all of which were non-HCW, possibly because all patients presenting with MERS had been infected in the community outside the health facility being studied. This outcome, with no infections among HCW, is an indication of the high*

					● *Improvements on IPC measures* ● *Continuous monitoring for effectiveness* ● *Administrative and leadership support* ● *Targeted resource allocation* ● *High HCW compliance rates* *Open lines of communication between involved parties*	*level of effectiveness of the prevention measures implemented in hospitals in Saudi Arabia. However, the presence of infection among patients from outside the health facility may reflect a situation where prevention measures applied in the community were less effective. Such infections could result from a lack of timely diagnosis and treatment and poor observance of other required practices such as personal hygiene.*
Effectiveness of the Middle East respiratory syndrome-coronavirus protocol in enhancing the function of an Emergency Department in Qatar	Varughese et al. (2015)19	Patients presenting to the emergency department (n = 100,751). Study undertaken in the ED of a tertiary hospital in Qatar.	To describe interventions implemented to prevent outbreak of MERS-CoV and limit its impact on the functioning of the ED.	Descriptive study	*Study undertaken for a period of two months (August to October 2013). Essential effective measures:* ● *Creation of MERS-CoV surveillance protocol and tracking system* ● *A MERS-CoV corona triage in*	*Due to the implementation of mandatory isolation procedures, no cross-infection was observed among patients and staff. This outcome proves that these procedures worked very well and are therefore important in the prevention and*

		the ED, staffed by healthcare professionals equipped with PPE ● *Staff training in isolation procedures* ● *ED worked with radiology department to prioritise probable MERS-CoV patients for CXR evaluation* *Establishment of new respiratory isolation rooms*	*control of MERS-CoV. Nevertheless, cases of patients infecting other patients were observed, indicating some deficiency in the ability of the implemented prevention measures. Essential effective measures:* ● *Revision, evaluation and continued monitoring and improvement of the effectiveness of infection prevention measures* ● *Triage and isolation* ● *Surveillance protocols* *Non-essential but useful measures:* ● *Educational posters about the symptoms of MERS.* ● *Training and education of HCW* ● *Establishment of administrative controls* ● *Establishment of environmental*

						controls (e.g., proper and consistent cleaning and disinfection measures) ● *Observation of workplace safety* *Establishment of engineering controls (e.g., partitions to guide patients in triage areas; curtains between patients who share a space; closed suctioning systems for intubated patients; installation and maintenance of proper air handling systems)*
Surveillance of the Middle East respiratory syndrome (MERS) coronavirus (CoV) infection in healthcare workers after contact with confirmed MERS patients: incidence and risk factors of MERS-CoV seropositivity	Kim et al. (2016)8	HCW (n = 737) in 31 MERS affected hospitals in South Korea	To evaluate MERS-CoV prevalence in exposed HCW and to calculate its incidence in HCW. To identify risk factors of MERS infection in HCW.	Descriptive study	*Tests were conducted for approx. Six weeks.* *Essential effective measures:* ● *Use of PPE (gown, gloves, masks)* *Isolation*	*Seropositivity for MERS-CoV was higher (0.7%) among HCW not using PPE compared with those using it (0%). This suggests the effectiveness of PPE in MERS-CoV IPC.* *Essential effective measures:* ● *Use of personal protective equipment such as N95 respirator,*

						isolation gown, gloves *Non-essential but useful measures: Screening*
Lack of transmission among healthcare workers in contact with a case of Middle East respiratory syndrome coronavirus infection in Thailand	Wiboonchutikul et al. (2016)20	HCW (n = 38) in a healthcare setting in Thailand. The mean age was 38.1 years, with females comprising 79% of the target population.	To assess the effectiveness of IPC interventions in reducing MERS-CoV transmission to HCW after exposure to a MERS patient or the patient's body fluids. The patient was an elderly man aged 74 years.	Descriptive study	*Study targeted HCW attending to the patient from June 18 to July 3, 2015.* *Essential effective measures:* ● *Isolation of patients* ● *Protection provided through use of disposable gloves* ● *Fit testing of N95 respirators* ● *Gowns* ● *Disposable caps* ● *Eye protection* ● *Maintenance of hand hygiene* *Non-essential but useful measures: Waste carefully managed and destroyed by incineration*	*None of those who were in contact with the patient tested positive for MERS. The results indicate the effectiveness of the infection control interventions implemented in the facility. The fact that the patient's MERS infection was identified beforehand might have helped to prevent cross-infection, since it allowed the institution to put in place the necessary precautions.* *Essential effective measures:* ● *Hand hygiene* ● *Use of N95 respirators* ● *Respirator fit tests* ● *Use of gloves* ● *Early identification and diagnosis* ● *Use of gowns*

						Use of eye protection and caps
A multi-faceted approach of a nursing led education in response to MERS-CoV infection	Al-Tawfiq et al. (2017)7	Nurses (n = 1,000) at John Hopkins Aramco Healthcare in Saudi Arabia; mean age and gender not provided.	To describe a nurse-led training programme	Report	*Duration of training not specified.* *Essential effective measures:* *The training programme included essential skills in:* ● *How to use PPE (gown, head cover, gloves, and N95 mask)* ● *Donning and doffing of PPE; hand hygiene* *Collection of nasopharyngeal specimens for MERS-CoV testing*	*Essential effective measures:* ● *HCW training* ● *Specified protocols to reduce MERS-CoV cross-infection and enhance the safety of patients and staff* ● *Use of PPE* ● *Triage and isolation* ● *Cohorting infected patients* *Although this report does not address the impact of the training on MERS-CoV transmission, it highlights the importance of training nurses in basic infection control procedures for control of MERS-CoV transmission.*

Outbreak of Middle East respiratory syndrome at tertiary care hospital, Jeddah, Saudi Arabia, 2014	Hastings et al. (2016)21	Inpatients (n = 2,776); ED patients (n = 15,218); HCW (total number not specified). Study conducted on 78 patients, HCW and other visitors, in Saudi Arabia, at King Fahd General Hospital (KFGH).	To investigate MERS illness clusters at King Fahd General Hospital and determine the number of cases acquired at the hospital; identify hospital areas of transmission; and evaluate the relationship between MERS cases and implementation of IPC measures.	Retrospective cohort observational study	*Study period was approx. two months (March 2 – May 10, 2014).* *Essential effective measures:* ● *Triage to isolate MERS patients* ● *Suspected and confirmed MERS patients placed in isolation rooms* ● *Use of PPE by HCW* ● *Dialysis shifts* *Non-essential but useful measures:* ● *Implementation of Ministry of Health infection control guidelines*	*78 persons acquired MERS-CoV:* *Patients (n = 53), HCW (n = 16), and visitors (n = 9).* *The outbreak at KFGH decreased sharply after week 7, following IPC improvements in the ED in week 6. In week 8, infection control was improved in the dialysis unit and a MERS unit was set up in a separate building.* *Essential effective measures:* ● *Physical separation of MERS patients and isolation in a different building* ● *Infection control precautions.* *All these measures might have led to reduced transmission of MERS-CoV.* *Most of the MERS cases outlined above were identified before IPC measures were implemented.* *However, it is not*

						clear why the hospital was slow in implementing the infection control measures. Non-essential but useful measures: Vigilance and continued adherence to infection control measures
Middle East respiratory syndrome coronavirus transmission among health care workers: Implications for infection control.	Alfaraj et al. (2017)22	HCW (n = 153) at Prince Mohamed Bin Abdulaziz Hospital (PMAH), Saudi Arabia. Population demographics not provided.	Investigation of MERS outbreak among HCW, including transmission pattern and contact tracing.	Descriptive study	*Study was conducted for a period of approx. 70 days. Essential effective measures:* ● *Comprehensive contact tracing Quarantining suspected individuals*	*A total of seven cases were found positive for MERS (3 from the index case; 1 from each of the four successive quarantines). Although contact tracing is a difficult activity due to the complexity of HCWs' interactions with patients and other people, the transmission of MERS could be traced over four generations and contained.*
Control of an outbreak of Middle East respiratory syndrome in a tertiary hospital in Korea	Park et al. (2016)23	MERS patients (n = 92); exposed persons (n = 9,793; HCW, visitors, security guards,	To describe the response to a MERS outbreak in a tertiary hospital, the outbreak's timeline, and	Descriptive study	*Study period was approx. two months (May to July 2015). Essential effective measures:*	*Of the 18 hospitalised persons under quarantine in phase 0, none acquired MERS-CoV. This was a strong indicator of the*

	transport workers, cleaners). Study undertaken in a tertiary hospital in Korea.	efforts to control it.	● *Rapid contact tracing of patients and staff exposed to MERS-CoV* ● *Isolation of those with close contact* ● *Active monitoring of those suspected to have had close contact* *Non-essential but useful measures:* ● *Asking those suspected of close contact to remain quarantined at home*	*success of the control measures used. In phase 1, 278 people were placed under quarantine with 617 others being closely monitored. From this number, 82 people were infected with MERS-CoV. These infections can be linked to a three-day delay in identifying the index secondary patient. In phase 2, a hospital patient transporter, who had been exposed to the secondary patient and had been omitted from the abovementioned contact tracing, was subsequently confirmed to have MERS. Contact tracing was performed, which led to 587 persons being quarantined and 4,988 being placed under active monitoring. However, none of these cases acquired MERS-CoV.*

			The transporter always wore standard medical masks and this might have prevented cross-infection. *Another patient, a security guard who was exposed to the secondary patient, was found to have MERS. This patient infected 3 HCW. All HCW (n = 591) were subsequently screened and 3 found to be asymptomatically infected. The HCW acquired MERS despite using PPE and this suggests that one control measure is not enough to prevent MERS-CoV transmission.* *Essential effective measures:* ● *Early detection* ● *Immediate contact tracing* ● *Isolation* ● *Avoidance of delays* ● *PPE (e.g.: masks)* *Combination of effective control*

	measures and protocols

Table 3. Appraisal of The Evidence Presented in The Various Studies

Critical Appraisal	
Appraisal Tool (Briggs, 2013)[24]	**Quality of Evidence**
Descriptive design	Weak
Descriptive design	Weak
Descriptive design	Weak
Descriptive design	Weak
Descriptive design	Weak
Observational design	Weak
Observational design	Weak
Observational design	Weak
Observational design	Weak
Report	Weak

Table 4. Appraisal of Basic Intervention Effectiveness

Intervention Type Alone	**No. of Studies Using It**	**Effectiveness**
Hand hygiene	Nil	N/A
Patient isolation (in standard rooms and in negative pressure rooms)	Nil	N/A
Personal protective equipment (PPE) such as face masks	Nil	N/A
Intervention Type Combined	**% of Studies Using It**	**Effectiveness**
Hand hygiene (combined with other measures)	50%	Moderate
Patient isolation (combined with other measures)	80%	High

PPE (combined with other measures)	90%	High

Table 5. Appraisal of Administrative Interventions

Intervention Type Alone	**% of Studies Using It**	**Effectiveness**
All	0%	N/A
Intervention Type Combined	**% of Studies Using It**	**Effectiveness**
HCW training	40%	High
Clinical triage	30%	Moderate
Contact tracing	30%	Moderate
Surveillance	30%	Moderate
Visitor control	30%	Moderate
IPC guidelines	30%	Moderate
IDEP	20%	Low
Suspension of surgeries	20%	Low
ED closure	20%	Low
Cleanliness	20%	Low
Outpatient service	10%	Low
Establishment of command centre	10%	Low
ED contingency plan	10%	Low
RRT visits	10%	Low

Table 6. Appraisal of the Effectiveness of Healthcare Interventions

Intervention Type Alone	**% of Studies Using It**	**Effectiveness**
Taking nasopharyngeal swabs	20%	Low
Isolating MERS patients in negative pressure rooms	20%	Low

Environmental and quipment hygiene	10%	Low
Closing the ED	10%	Low

Intervention Type Combined	**% of Studies Using**	**Effectiveness**
Taking nasopharyngeal swabs combined with isolating MERS patients in negative pressure rooms	60%	Moderate
Environmental and equipment hygiene combined with closing the ED	50%	Moderate
All interventions combined	90%	High

Appendix 1. Search Strategy and Results

PubMed Database Search

Date	**Search Terms**	**Search Results (Hits)**	**Retrieved Articles**
14/01/2018	"MERS-CoV" AND "control" AND "hospital"	127	2
14/01/2018	"response" AND "MERS" AND "outbreak" AND "hospital"	18	5
14/01/2018	Middle east respiratory syndrome exposed hospital Saudi Arabia	8	2
14/01/2018	"health care workers" AND "hospital" AND "MERS" AND "outbreaks" AND "Saudi Arabia"	5	4
14/01/2018	"effectiveness" AND "control" AND "Middle East respiratory syndrome-coronavirus"	12	6
14/01/2018	"nursing" AND "response" AND "MERS-CoV" AND "infection"	1	1
14/01/2018	"MERS" AND "hospital" AND "outbreak" AND "prevention and control"	33	7
15/01/2018	"prevention" AND "MERS" AND "transmission" AND "outbreak"	49	9
15/01/2018	"critical care" AND "MERS" AND "infection control"	9	3
15/01/2018	"critical response" AND "MERS"	0	0
15/01/2018	"hand hygiene" AND "Middle east respiratory syndrome"	9	4
	Total	271	43

ScienceDirect Database Search

Date	Search Terms	Search Results (Hits)	Retrieved Articles
15/01/2018	"infection control and prevention" AND "Middle East respiratory syndrome"	24	8
15/01/2018	"infection prevention and control" AND "Middle East respiratory syndrome"	79	16
15/01/2018	"outbreak" AND "Middle East respiratory syndrome corona virus" AND "Saudi Arabia"	254	17
15/01/2018	"hand hygiene" AND "MERS" AND "outbreak"	132	12
15/01/2018	"patient isolation" AND "MERS" AND "outbreak"	24	1
15/01/2018	"disaster planning" AND "MERS"	43	1
15/01/2018	"critical care" AND "MERS"	631	2
16/01/2018	Infectious Disease Epidemic Plan hospital MERS	545	3
16/01/2018	"personal protective equipment" AND "Middle East respiratory syndrome" AND "hospital"	116	15
	Total	1848	75

BioMed Central Database Search

Date	Search Terms	Search Results (Hits)	Retrieved Articles
16/01/2018	"control" AND "Middle East respiratory syndrome"	123	8
16/01/2018	"infection prevention and control" AND "Middle East respiratory syndrome"	14	4
16/01/2018	"management" AND "Middle East respiratory syndrome" AND "outbreak"	53	5
16/01/2018	"critical care" AND "Middle East respiratory syndrome" AND "outbreak"	10	3
16/01/2018	"prevention" AND "transmission" AND "Middle East respiratory syndrome"	56	5
16/01/2018	"response" AND "hospital" AND "Middle East respiratory syndrome"	51	4
16/01/2018	"hygiene protective equipment MERS"	12	3
16/01/2018	disaster planning MERS	11	1
16/01/2018	**Total**	330	33

Taylor & Francis Online Database Search

Date	Search Terms	Search Results (Hits)	Retrieved Articles
16/01/2018	"control" AND "transmission" AND "MERS-CoV"	51	5
16/01/2018	"infection control" AND "hospital" AND "MERS-CoV"	13	6
16/01/2018	"critical care" AND "MERS-CoV"	0	0
16/01/2018	"hand hygiene" AND "MERS-CoV"	6	2
	Total	70	13

Sage Journals Database Search

Date	Search Terms	Search Results (Hits)	Retrieved Articles
16/01/2018	Middle East respiratory syndrome coronavirus	87	4
	Total	87	4

CDC (Centers for Disease Control and Prevention) Search

Date	Search Terms	Search Results (Hits)	Retrieved Articles
16/01/2018	Outbreak Middle East respiratory syndrome hospital Saudi Arabia	460	6
	Total	460	6

WHO (World Health Organization) Search

Date	Search Terms	Search Results (Hits)	Retrieved Articles

16/01/2018	control Middle East respiratory syndrome outbreak	3	0
	Total	3	0

Ministry of Health (Kingdom of Saudi Arabia) Search

Date	Search Terms	Search Results (Hits)	Retrieved Articles
16/01/2018	infection control Middle East respiratory syndrome	90	3
	Total	90	3