Does health economics research align with the disease burden in the Middle East and North Africa region? A systematic review of economic evaluation studies on public health interventions

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Abstract

Introduction: Economic evaluation studies demonstrate the value of money in health interventions and enhance the efficiency of the healthcare system. Therefore, this study reviews published economic evaluation studies of public health interventions from 26 Middle East and North Africa (MENA) countries and examines whether they addressed the region's major health problems.

Methods: PubMed and Scopus were utilized to search for relevant articles published up to June 26, 2021. The reviewers independently selected studies, extracted data, and assessed the quality of studies using the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) checklist.

Results: The search identified 61 studies. Approximately half (28 studies; 46%) were conducted in Israel and Iran. The main areas of interest for economic evaluation studies were infectious diseases (21 studies; 34%), cancers (13 studies; 21%), and genetic disorders (nine studies; 15%). Five (8%), 39 (64%), 16 (26%), and one (2%) studies were classified as excellent, high, average, and poor quality, respectively. The mean of CHEERS checklist items reported was 80.8% (SD 14%). Reporting the structure and justification of the selected model was missed in 21 studies (37%), while price and conversion rates and the analytical methods were missed in 21 studies (34%).

Conclusions: The quantity of economic evaluation studies on public health interventions in the MENA region remains low; however, the overall quality is high to excellent. There were obvious geographic gaps across countries regarding the number and quality of studies and gaps within countries concerning disease prioritization. The observed research output, however, did not reflect current and upcoming disease burden and risk factors trends in the MENA region.

Keywords: Cost-effectiveness, Economic evaluation, Middle East, North Africa, Public health

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to control vectors, control tobacco and alcohol, detect diseases, promote regular exercise and a healthy lifestyle, prevent injury and avoid risky behaviors, are deemed health interventions that could improve overall health, longevity, and productivity of communities [2, 3]. Despite their effectiveness in most cases, these public health interventions always need resources. With a limited health care budget, implementing such interventions must compete with other interventions for the same resources. Thus, to maximize health outcomes within a limited budget, health technology assessment (HTA), particularly health economics (HE) or economic evaluation studies which provide value for money derived from the investment, plays an important role in informing healthcare resource allocation decisions [4, 5]. However, compared to other health interventions, there is limited evidence in economic evaluation studies on public health intervention [4].

Despite its current limited role in policy decision-making, the number of HE articles published in the Middle East and North Africa (MENA) countries has recently increased and begun to attract the interest of policy-makers to inform priority-setting toward achieving universal health coverage (UHC) in many countries [6]. Similar to other regions, the growing demand for such kind of evidence in MENA is mainly driven by several factors, including rising healthcare costs as a result of remarkable advances and high costs of healthcare technologies, the World Health Organization (WHO)'s recommendations on the use of HTA, and the movement towards evidence-based healthcare system [5, 7]. Hence, in the face of the inevitable pressures from competing for alternative interventions, countries should direct their finite health budgets to meet the priority health needs of their populations to reach fair and efficient outcomes [8].

Furthermore, the burden of diseases and their background risk factors in the MENA region have shifted dramatically in the past decades, with wide variation across countries [9–11]. The region is also dealing with an epidemiological shift in burden from infectious to chronic diseases. In addition, some communicable diseases have recently re-emerged [12]. In the meantime, cardiovascular diseases (CVDs), cancers, diabetes mellitus, chronic kidney diseases, and chronic lung diseases represent a significant disease burden in the MENA region and pose a growing threat to public health [13]. These diseases impose enormous pressures on the health system and resources. Moreover, this burden increases with alarming future prevalence projections of up to 2.4 million deaths from the diseases mentioned earlier in the region in 2025 [14]. Coupled with ongoing wars and turmoil, several risk factors affect the people's health in this region [9]. In this regard, MENA has some of the highest rates of non-communicable diseases (NCDs)-risk factors, such as high blood pressure, obesity, physical inactivity, tobacco use, and high intake of salt, sugar and fats, along with the absence of an efficient surveillance system for early-stage disease detection in most countries [15]. Therefore, MENA countries need integral strategies built on existing expertise and projects to handle the existing health challenges and the ones that may occur in the future.

Based on this background, this study aims to systematically review the characteristics and critically assess the quality of economic evaluation studies on public health interventions in MENA countries. It also aims to examine whether the economic evaluation studies have addressed the major health problems and are suitable for policy decision-making in the region. The findings of this study may support existing evidence for better allocating healthcare and research resources in the region.

Methods

This review was reported following the Preferred Reporting Items for Systematic Review and Meta-analyses (PRISMA) statement [16].

Data sources and search strategy

The researchers searched the literature in PubMed and Scopus for relevant articles published since databases inception up to June 26, 2021. The search strategy involved combining terms for public health interventions and economic evaluations using the Boolean ‘AND’, ‘OR’, and ‘NOT’ operators. The term "public health" was purposefully broad, and the authors expected that it would incorporate a wide array of interventions in the field. Search terms used involved the combination of the following Medical Subject Heading (MeSH) terms and keywords: (health promotion [MeSH]) OR (public health intervention [Title/Abstract]) OR (Exercise [MeSH]) OR (smoking cessation [MeSH]) OR (Mass Screening [MeSH]) OR (prevention [Title/Abstract]) OR (tobacco control [Title/Abstract]) OR (Public Policy [MeSH]) AND (cost [MeSH]) OR (Cost–Benefit Analysis [MeSH]) OR (economic evaluation [Title/Abstract]) AND (Middle East [MeSH]) OR (North Africa [MeSH]) OR (Djibouti [Title/Abstract]) OR (Mauritania [Title/Abstract]) OR (Pakistan [Title/Abstract]) OR (Palestine [Title/Abstract]) OR (Sudan [Title/Abstract]) OR (Somalia [Title/Abstract]) NOT (vaccine [MeSH]) OR (vaccination [MeSH]) OR (immunization [MeSH]) OR (immunization program [Title/Abstract]) OR (immunoprophylaxis [Title/Abstract]). The search was restricted to journal articles, studies of human subjects, and studies written in the English language.

Eligibility criteria

Economic evaluation studies (cost–benefit analyses, cost-effectiveness analyses, cost-minimization analyses, and cost-utility analyses) of public health interventions available in
full text, published in English, and about at least one country in the MENA region were included in this review. In this study, the researchers adopted the comprehensive definition of the MENA region [17], which included 24 countries (i.e., Afghanistan, Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, United Arab Emirates, and Yemen). Besides, Turkey and Israel were added to the analysis as they were involved in PubMed (MeSH) definition of the Middle East region. Meanwhile, cost of illness studies and other partial economic evaluation studies were excluded. The researchers also excluded the full economic evaluation studies on vaccines (unless screening was one of the comparators) and diagnostic and therapeutic interventions. These interventions were reviewed separately in other manuscripts to ensure harmony and consistency of compared studies, thus, gaining more insight into the specific characteristics of each group of interventions [18, 19].

Study selection and data extraction
Study selection was performed independently by two reviewers (MAN and SS) according to the exclusion and inclusion criteria; first by title, followed by abstract, and finally by full-text screening. Discrepancies were resolved by discussion and consensus with another reviewer (MT). Then, identified studies were screened independently by two reviewers (MAN and MAAR) to extract (1) general information (e.g., year and country of publication, author’s affiliation, disease/risk factor domain, type of analysis, the model used, and interventions and comparators assessed); (2) methodological characteristics (e.g., the year of estimation, study population, perspective, time horizon, the discount rate, model’s internal validity, double-counting, and the type of sensitivity analysis performed); (3) source of input parameters (e.g., epidemiology, effectiveness, utility, and cost data). In addition, the source of funding, result and conclusion, cost-effectiveness threshold, and types of included costs were also extracted. Any disagreements were resolved in discussion with another reviewer (MT).

Quality assessment and appraisal
The methodological and reporting quality of each included economic evaluation study was assessed by two independent reviewers (MAN, PEND). Disagreement was resolved by discussion and consensus with the third reviewer (MT). Studies were assessed for their quality of reporting by their compliance with the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) statement [20]. Studies were then scored against each of the applicable 24 checklist items according to whether reporting was fully satisfied or did not satisfy the item requirements. Each reporting quality criterion was rated as reported (score = +), not reported if the item was missing when expected to be reported (score = −) or not applicable (NA). Subsequently, studies were classified by their percentage of applicable items as “excellent”, “high”, “average”, or “poor” quality when they fulfilled 100%, 76–99%, 50–75%, or less than 50% of the CHEERS checklist items, respectively [18]. The overall quality of reporting was presented as a percentage score of applicable items. Studies scoring above 75% were considered of higher reporting quality.

Data management and analysis
EndNote X8 software was utilized for duplicate removal. All data extracted from the final list of included studies were entered into a pre-designed data extraction form in Microsoft Excel 2013 spreadsheet. Data synthesis involved stratifying and summarizing the evidence by intervention type, appraising the economic evaluation methods used to assess interventions, and presenting the cost-effectiveness outcomes. Then, descriptive statistics were used with percentages, mean, standard deviation (SD), and median to display the results of extracted data and evaluated items obtained in this review.

Results
Search results
In total, 849 studies were identified following the initial search (i.e., 388 from PubMed and 461 from Scopus). The removal of 69 duplicates resulted in 780 remaining articles. Title and abstract screening resulted in the removal of 623 papers and left 157 potentially relevant studies for full article text screening. Finally, 61 studies [21–81] were included in this review. The reasons for exclusion in each step are provided in the PRISMA flowchart in Fig. 1.

General and methodological characteristics
This review identified economic evaluation studies on screening programs (36 studies; 59%) [21, 22, 24, 26, 28–31, 33–37, 39, 41, 45, 48–52, 54–56, 58, 60, 63–65, 70, 71, 73, 74, 79–81] and health promotion campaigns (four studies; 7%) [40, 46, 59, 78]. In addition, two studies concerned vector control programs [43, 68] and two studies for smoking cessation interventions [57, 66] (3% each), while the remaining 17 studies (28%) focused on other different interventions, as shown in Table 1. The main areas of interest for economic evaluation studies identified in this review were infectious diseases (21 studies; 34%) [21, 22, 25, 28–31, 33, 38, 39, 43, 44, 50, 55, 61, 62, 67, 68, 72, 75, 76], cancers (13 studies; 21%) [26, 34, 35, 37, 41, 45, 51, 54, 60, 63, 69, 71, 73], genetic disorders (nine studies; 15%) [36, 48, 49, 52, 64, 65, 70, 74, 79], CVDs (seven studies; 12%) [24, 40, 46, 59, 78, 80, 81], gestational diabetes mellitus (two studies; 3.3%) [56, 58], maternal
**Fig. 1 PRISMA flow chart of search procedure**

- **Identification**
  - PubMed: n = 388
  - Scopus: n = 461
  - Duplicate Exclusion: n = 69

- **Screening**
  - Articles screened by title and abstract: n = 780
  - 623 Records excluded as:
    - Epidemiological studies: 217
    - Policy recommendations: 275
    - Clinical studies: 117
    - Outside health sector: 9
    - Review articles: 5

- **Eligibility**
  - Potentially relevant articles: n = 157
  - 96 Records excluded as:
    - Cost of Illness studies: 75
    - EE of therapeutic intervention: 10
    - Outside MENA: 5
    - Not available in full text: 6

- **Included**
  - Number of studies included for review: n = 61

*MENA = Middle East and North Africa; EE = Economic Evaluation*
| Author (references) | Country | Publication year | Affiliation | Domain | Type of study | Model used | Intervention and comparator |
|---------------------|---------|-----------------|-------------|--------|---------------|------------|-----------------------------|
| Adibi et al. [21]   | Iran    | 2004            | National    | Infectious | CEA (per infection averted) | Decision tree | HBsAg screening for all premarriage individuals and prevention protocol for seronegative subjects or HBsAg screening for all premarriage individuals, HbcAb screening in the HBsAg negative spouses of the HBsAg positive persons, and prevention protocol Vs no screening and no prevention |
| Al Abri et al. [22] | Oman    | 2020            | National and International | Infectious | CUA (per QALY) | Decision tree and Markov | Different testing programs using an IGRA versus the TST, combined with QFT-Plus with 6H, QFT-Plus with 3HP, QFT-Plus with 4R, TST with 6H, TST with 3HP and directly observed therapy, TST with 4R Vs CXR alone |
| Al-Qudah et al. [23] | Jordan  | 2019            | National and International | NCDs | CBA | NA | Clinical pharmacist intervention (home medication management review, patient education on drug-drug interactions, dosage adjustment, patient education on the importance of adherence to their medication regime, etc.) Vs routine care |
| Assanelli et al. [24] | Algeria and others | 2015 | National and International | CVDs | CEA (per LYG) | NR | ECG in combination with family and personal history and physical examination (no comparator was reported) |
| Author (references) | Country | Publication year | Affiliation | Domain | Type of study | Model used | Intervention and comparator |
|---------------------|---------|------------------|-------------|--------|---------------|------------|-------------------------------|
| Balicer et al. [25] | Israel  | 2005             | National    | Infectious | CBA           | NA         | 3 strategies for the use of stockpiled antiviral drugs during a pandemic (1) therapeutic use, (2) long-term preexposure prophylaxis, and (3) short-term postexposure prophylaxis for close contacts of influenza patients |
| Barfar et al. [26]  | Iran    | 2014             | National    | Cancer    | CEA (per case detected) | NR         | Mammography breast cancer screening Vs no screening |
| Carvalho et al. [27]| Afghanistan | 2013          | National and International | Maternal diseases | CEA (per LYS) | Decision tree | Family planning strategies Vs combined several interventions (Integrated reproductive health and pregnancy-related services) |
| Chodick et al. [28]| Israel  | 2005             | National    | Infectious | CEA (per case avoided) | Decision tree and Markov | Mass Varicella zoster virus vaccination, screening followed by vaccination, vaccination of carriers and do nothing (status quo situation) |
| Chodick et al. [29]| Israel  | 2002             | National    | Infectious | CUA (per QALY) | Decision tree and Markov | Mass Hepatitis A vaccination, screening and vaccination Vs passive immunization (status quo strategy) |
| Chowers [30]        | Israel  | 2017             | National    | Infectious | CUA (per QALY) | Decision tree and Markov | Universal prenatal HIV screening compared with the current high risk only screening policy |
| Devine [31]         | Afghanistan and others | 2020         | International | Infectious | CUA (per DALY) | Decision tree | Gender-based treatment according to qualitative G6PD rapid diagnostic screening Vs routine care |
| El-Dahiyat [32]     | Jordan  | 2017             | National    | All      | CMA           | NA         | Generic medicines Vs originator brand medicines |
| El-Ghitany [33]     | Egypt   | 2019             | National    | Infectious | CEA (per test performed) | NR         | EGCRISC use Vs mass screening |
Table 1 (continued)

| Author (references) | Country     | Publication year | Affiliation | Domain    | Type of study | Model used | Intervention and comparator                                                                 |
|---------------------|-------------|------------------|-------------|-----------|---------------|------------|-------------------------------------------------------------------------------------------|
| Eltabbakh et al. [34] | Egypt       | 2015             | National    | Cancer    | CUA (per QALY) | NR         | HCC screening program by ultrasound and alpha-fetoprotein Vs diagnosis outside the program |
| Gamaoun et al. [35]  | Tunisia      | 2018             | National    | Cancer    | CEA (per case avoided) | Decision tree | Two-dose HPV vaccine for young girls Vs screening with three time-lapse Pap smear test     |
| Ginsberg et al. [36] | Israel      | 1998             | National    | Genetic disorders | CBA | NA | Combined educational and national prenatal screening programs for thalassemia by blood samples test then electrophoresis for samples with abnormal values followed by counselling Vs no screening |
| Ginsberg et al. [37] | Israel      | 2013             | National    | Cancer    | CUA (per DALY) | Markov     | Screening with removal of cancerous lesions, Three doses of HPV vaccine with or without booster dose every 20 years for 12-year old girls, treatment of all cancer cases, and combinations of these interventions in different scenarios Vs current policy (Treat all cases and annual screening of 12.1% of females aged 12–70 with Pap smear) |
| Ginsberg et al. [38] | Israel      | 2020             | National    | Infectious | CUA (per DALY) | Decision tree | Continuous HIV pre-exposure prophylaxis regimen Vs on-demand HIV pre-exposure prophylaxis |
| Author (references) | Country       | Publication year | Affiliation     | Domain     | Type of study   | Model used     | Intervention and comparator |
|---------------------|---------------|------------------|-----------------|------------|-----------------|----------------|-------------------------------|
| Ginsberg et al. [39]| Israel        | 2007             | National        | Infectious | CUA (per QALY)  | Markov         | Screening with Pap smear (annually, tri-annually and penta-annually), HPV-DNA testing, or Visual inspection with acetic acid (VIA) - All followed by removal of cancerous lesions, prevention by vaccination (3 doses of HPV vaccine with or without booster dose every 10 years for 12-year old girls), treatment of all cancer cases, screening and treatment, vaccination and treatment, and combination of prevention, screening and treatment. All strategies Vs current policy (all cases are treated and 12.2% of females aged 12–70 receive Pap smear) |
| Ginsberg et al. [40]| Israel        | 2012             | National        | CVDs       | CUA (per DALY)  | NR             | Home, school, workplace, restaurant and supermarket-based interventions, screening, media strategies, taxation of unhealthful food products, provision of government subsidies to reduce the price of healthful foods [and vice-versa], mandatory food labeling, and prohibiting the sale of unhealthful foods in vending machines |
| Haghighat et al. [41]| Iran         | 2016             | National and international | Cancer | CUA (per QALY) | Decision tree and Markov | Mammography screening strategy Vs no screening |
| Hamdani et al. [42]| Pakistan     | 2020             | National and international | Mental diseases | CEA (per unit change in anxiety, depression and functioning scores) | NR | Problem Management + Vs enhanced usual care |
| Author (references) | Country | Publication year | Affiliation | Domain      | Type of study | Model used | Intervention and comparator |
|---------------------|---------|------------------|-------------|-------------|---------------|------------|--------------------------------|
| Howard et al. [43]  | Pakistan | 2017             | National and International | Infectious | CUA (per DALY), CEA (per LYG, case prevented, death prevented) | NR | Vector control using annual indoor residual spraying Vs routine malaria diagnosis and treatment |
| Hussain et al. [44] | Pakistan | 2019             | International | Infectious | CUA (per DALY), CEA (per patient treated) | Decision tree and Markov | Active case finding program using incentives Vs the existing passive case finding and treatment program |
| Javadinasab et al. [45] | Iran | 2017             | National | Cancer | CUA (per QALY) and CEA (per LYG) | Markov | Colonoscopy screening every 5 years starting at age 40, screening every 10 years starting at age 40, screening every 5 years starting at age 50, screening every 10 years starting at age 50, screening once/lifetime at age 50, and screening once/lifetime at age 55 Vs no screening |
| Javanbakht [46]     | Iran | 2018             | National and International | CVDs | CEA (per capita health-care cost) | Markov | Adequate dairy foods consumption Vs inadequate dairy foods consumption |
| Kashi et al. [47]   | Pakistan and others | 2019          | International | Malnutrition | CUA (per DALY) | Decision tree | Multiple micronutrient supplementation Vs iron and folic acid supplementation |
| Khneisser et al. [48] | Lebanon | 2015            | National | Genetic disorders | CBA | NA | Expanded newborn screening for inborn errors of metabolism by using tandem mass spectrometry followed by diagnostic confirmation and management Vs clinical “late” detection |
| Khneisser et al. [49] | Lebanon | 2007            | National | Genetic disorders | CBA | NA | G6PD deficiency screening Vs no screening |
| Author (references) | Country | Publication year | Affiliation | Domain | Type of study | Model used | Intervention and comparator |
|---------------------|---------|-----------------|-------------|--------|---------------|------------|-----------------------------|
| Kim et al. [50]     | Egypt   | 2015            | National and International | Infectious | CUA (per QALY) | Decision tree and Markov | One-time screening and follow-up treatment for HCV infection Vs the current strategy of no screening |
| Kim et al. [51]     | Algeria, Lebanon, and Turkey | 2013 | National and International | Cancer | For vaccination: CUA (per DALY). For screening: CEA (per LYS) | Decision tree | Three doses of HPV vaccine for all 12-year girls in MENA countries and combination of screening and vaccination in Algeria, Lebanon, and Turkey Vs no intervention |
| Koren et al. [52]   | Israel  | 2014            | National | Genetic disorders | CEA (per case prevented) | NR | Thalassemia prevention program Vs routine treatment of β Thalassemia major and its complications |
| Lahiri et al. [53]  | MENA and others | 2005 | International | Back pain | CEA (per LYG) | Markov | Worker training, engineering controls coupled with administrative controls, a combination of worker training and engineering controls, and the full ergonomics program Vs no intervention |
| Leshno et al. [54]  | Israel  | 2003            | National | Cancer | CEA | Markov | One-time colonoscopic screening, colonoscopy followed by a 10-year follow-up, annual FOBT, annual FOBT and flexible sigmoidoscopy, and annual detection of altered human DNA in stool Vs no screening |
| Lim et al. [55]     | Pakistan | 2020 | National and international | Infectious | CEA (per cured case) | Markov | HCV Screening and treatment Vs no interventions |
| Lohse et al. [56]   | Israel and others | 2011 | International | DM | CUA (per DALY) | Decision tree | Gestational diabetes mellitus screening and lifestyle change Vs no intervention |
| Author (references) | Country                              | Publication year | Affiliation          | Domain    | Type of study | Model used | Intervention and comparator                                                                 |
|---------------------|--------------------------------------|------------------|----------------------|-----------|---------------|------------|-----------------------------------------------------------------------------------------------|
| Madae'en et al. [57] | Jordan                               | 2020             | National             | Smoking   | CEA (per LYG) | Markov     | Varenicline for 3 months, NRT (combined patch and gum) for 3 months, and physician advice over three visits with no medications Vs no intervention |
| Marseille et al. [58]| Israel and others                    | 2013             | National and interna-| DM        | CUA (per DALY) | Decision tree | Initial screening tests, antenatal care for Gestational DM women, and post-partum DM prevention interventions Vs no Gestational DM screening and treatment |
| Mason et al. [59]   | Tunisia, Syria, Palestine and Turkey | 2014             | National and Interna-| CVDs      | CEA (per LYG) | Decision tree | Health promotion campaign, labelling of food packaging or mandatory salt reduction of processed foods Vs no policy |
| Messoudi et al. [60] | Morocco                              | 2019             | National and Interna-| Cancer    | CEA (per LYG) | Markov     | Screening of women aged 30–49 years with a VIA test every 3 years Vs no intervention, two doses of HPV vaccine for pre-adolescent girls Vs no intervention, and combined HPV vaccine and screening Vs screening alone |
| Mostafa et al. [61] | Egypt                                | 2019             | National and Interna-| Infectious| CUA (per QALY) | Decision tree and Markov | Safety-engineered syringes Vs conventional syringes |
| Mostafa et al. [62] | Egypt                                | 2019             | National             | Infectious| CUA (per QALY) | Decision tree | Safety-engineered syringes Vs conventional syringes |
| Nahvijou et al. [63]| Iran                                 | 2016             | National and Interna-| Cancer    | CUA (per QALY) | Markov     | 11 different screening strategies with different periodicities and different intervals Vs no screening |
| Author (references) | Country | Publication year | Affiliation | Domain | Type of study | Model used | Intervention and comparator |
|---------------------|---------|------------------|-------------|--------|---------------|------------|-----------------------------|
| Okem et al. [64]    | Turkey  | 2017             | National    | Genetic disorders | CEA (per cases detected or procedural related losses avoided) | Decision tree | For women < 35-year of age: triple test, combined test, Non-invasive Prenatal Screening Test (NIPT) by using cell free fetal DNA, NIPT as a second-step screening for high-risk patients detected by triple test, and NIPT as a second-step screening for high-risk patients detected by combined test. For women ≥ 35-year of age: implementing invasive test (amniocentesis) and NIPT for all women were compared Vs current screening strategies |
| Ornoy et al. [65]   | Israel  | 2019             | National    | Genetic disorders | CBA         | NA         | National screening program for attention deficit hyperactivity disorder among school children and continue treatment until adulthood. The comparator was not reported |
| Ranson et al. [66]  | MENA    | 2002             | International | Smoking     | CUA (per DALYs) | NR         | Price increases, NRT, and a package of non-price interventions other than NRT (such as comprehensive bans on advertising and promotion; bans on smoking in public places; prominent warning labels and mass consumer information). The comparator was not reported |
| Rashidian et al. [67]| Iran    | 2015             | National    | Infectious | CEA (per percentages of volume reduction and weight reduction) | Decision tree | Medical waste treatment devices called Saray 1, Saray 2, Sazgar, KAZU, Newster, Ecodas T150, Ecodas T300, and Newster 10, Vs Caspian-Alborz |
| Author (references) | Country | Publication year | Affiliation | Domain | Type of study | Model used | Intervention and comparator |
|---------------------|---------|-----------------|-------------|--------|---------------|------------|------------------------------|
| Rezaei-Hemami et al. [68] | Iran | 2014 | National | Infectious | CEA (per averted malaria case) | NR | Larviciding, indoor residual spraying, insecticide treated net, set up the diagnosis and treatment in less than 24 h, and set up the border facilities Vs each other |
| Saygili et al. [69] | Turkey | 2019 | National | Cancer | CEA (per quality of life unit and level of satisfaction) | NR | Comprehensive palliative care center, hospital inpatient services, and home healthcare services Vs each other |
| Shamshiri et al. [70] | Iran | 2012 | National and International | Genetic disorders | CUA (per DALY) | Decision tree | Congenital hypothyroidism screening programs Vs no screening |
| Sharma et al. [71] | Lebanon | 2017 | National and International | Cancer | CEA (per LYS) | Markov | Increasing cytologic screening coverage to 50% at 3 and 5 years interval Vs annual screening at 20% coverage |
| Shlomai et al. [72] | Israel | 2020 | National | Infectious | CUA (per QALY) and CEA (per death prevented) | Markov | Social distancing and national lockdown Vs complete isolation of infected individuals or individuals at high exposure risk in a dedicated facility |
| Shmueli et al. [73] | Israel | 2013 | National and International | Cancer | CUA (per QALY) | Decision tree | Low-dose computed tomography screening Vs no screening |
| Sladkevicius et al. [74] | Libya | 2010 | National and International | Genetic disorders | CEA (per DYG) | Decision tree | Neonatal screening for Phenylketonuria Vs no screening |
| Verguet et al. [75] | Djibouti, Mauritania, Somalia, Sudan and others | 2013 | International | Infectious | CUA (per DALY) | Markov | Adding HIV pre-exposure prophylaxis at pre-existing levels Vs existing HIV prevention interventions (male circumcision, antiretroviral therapy and condom use) |
| Author (references)       | Country              | Publication year | Affiliation   | Domain          | Type of study                | Model used       | Intervention and comparator                                                                 |
|--------------------------|----------------------|------------------|---------------|-----------------|-----------------------------|------------------|----------------------------------------------------------------------------------------------|
| Vijayaraghavan et al. [76] | Afghanistan          | 2006             | International | Infectious      | CEA (per deaths averted)    | Markov           | Catch-up and follow-up measles campaigns Vs no measles campaigns                               |
| Vijayaraghavan et al. [77] | Somalia              | 2012             | International | Maternal diseases | CEA (per LYG) | NR                        | Child health days strategy to deliver multiple maternal and child health interventions Vs “best buys” interventions |
| Wilcox et al. [78]       | Syria                | 2015             | National and International | CVDs | CEA (per LYG) | Decision tree | Health promotion campaign about salt reduction, labeling of salt content on packaged foods, reformulation of salt content within packaged foods, and combinations of the three strategies Vs absence of any policy. |
| Yarahmadi et al. [79]    | Iran                 | 2010             | National      | Genetic disorders | CBA | NA                        | Newborn screening program for congenital hypothyroidism Vs no screening                       |
| Yosefy et al. [80]       | Israel               | 2007             | National      | CVDs            | CUA (per DALY) | NR                        | Nationwide program to reduce hypertension Vs no intervention                                 |
| Yosefy et al. [81]       | Israel               | 2003             | National      | CVDs            | CUA (per QALY) | NR                        | Expansion of the blood pressure control program to 100 clinics nationwide Vs 30 clinics only |

3HP 3 months of weekly rifapentine 900 mg plus isoniazid 900 mg, 6H 6 months of daily isoniazid 300 mg, 4R 4 months of daily rifampcin 600 mg, HBCaB hepatitis B core antibody, HBSaG hepatitis B surface antigen, CBA cost–benefit analysis, CEA cost-effectiveness analysis, CMA cost-minimization analysis, CUA cost-utility analysis, CVDs cardiovascular diseases, CXR chest X-ray, DALYs disability adjusted life years, DM diabetes mellitus, ECG electrocardiogram, EGCWSC Egyptian hepatitis C virus risk score screening tool, FOBT fecal occult blood test, G6PD glucose-6-phosphate dehydrogenase, HCC hepatocellular carcinoma, HCV hepatitis C virus, HPV human papillomavirus, HPV-DNA human papillomavirus DNA assay, IGRA interferon gamma release assay, LYG life years gained, LYS life years saved, MENA Middle East and North Africa, NA not applicable, NCDs noncommunicable diseases, NIPT non-invasive prenatal screening test, NR not reported, NRT nicotine replacement therapy, Pap smear Papanicolaou test, QALYs quality-adjusted life years, QFT-Plus QuantIFERON-TB gold plus, TST tuberculin skin test, VIA visual inspection with acetic acid, Vs versus
issues (two studies; 3.3%) [27, 77], tobacco control (two studies; 3.3%) [57, 66], and other domains (five studies; 8%) [23, 32, 42, 47, 53]. Regionally, all disease domains that accounted for the highest burden (i.e., CVDs, cancers, diabetes, chronic kidney and lung diseases, and nutritional diseases and injuries) had not been adequately studied or even not studied at all in some MENA countries. Similarly, the most prevalent risk factors (smoking, physical inactivity, obesity, high blood pressure, and high intake of salt, sugar and fats) were not studied in almost all MENA countries.

Geographically, this review identified 18 studies (30%) from Israel [25, 28–30, 36–40, 52, 54, 56, 58, 65, 72, 73, 80, 81], ten studies (16%) from Iran [21, 26, 41, 45, 46, 63, 67, 68, 70, 79], and five studies from Egypt [33, 34, 50, 61, 62] and Pakistan [42–44, 47, 55] (8% each). Further, the researchers obtained three studies from Afghanistan [27, 31, 76], Jordan [23, 32, 57] and Lebanon [48, 49, 71] (5% each) and two studies (3%) from Turkey [64, 69]. Only one study was identified from Algeria [24], Libya [74], Morocco [60], Oman [22], Somalia [77], Syria [78] and Tunisia [35] (12% all). Additionally, five studies (8%) were conducted in more than one MENA country [51, 53, 59, 66, 75], as shown in Table 1. In this review, 57 studies (93.4%) found public health interventions to be cost-effective or even cost-saving while only four studies (6.6%) reported non-cost-effective outcomes. The general and methodological characteristics along with the data extracted from the included studies are presented in Tables 1, 2 and 3.

**Quality assessment**

Table 4 presents the quality assessment results using the CHEERS checklist. Overall, study quality was good, with a median of 82.6% of applicable items being met (SD 14%). Forty-four studies (72%) achieved scores above an arbitrary threshold of 75%; therefore, they were considered high quality and potentially useful in policy decision-making [18, 19, 82]. The mean (SD) of items reported was 80.8% (14%). The evaluation of reporting adequacy guided by the CHEERS checklist resulted in scores ranging from 8 (35%) to 24 (100%), as shown in Table 4. Of the 61 studies included in this review, five studies (8%) [21, 41, 44, 51, 60] were deemed to be of excellent quality and 39 studies (64%) [22–24, 26–31, 36–40, 42, 43, 45–47, 50, 53–55, 57–59, 61–63, 66, 67, 70–74, 76–78] of high quality. However, 16 studies (26%) [25, 32, 34, 35, 48, 49, 52, 56, 64, 65, 68, 69, 75, 79–81] and one study (2%) [33] were incomplete with respect to important methodological details and were considered to be of average and poor quality, respectively.

Against applicable CHEERS items of each study, 21 studies (37%) did not explicitly mention the modeling approach and did not provide the model structure (item 15). Data on the quantities and unit costs of the resources used, the methods of currency conversion and the exchange rates (item 14), the description of the analytical methods supporting the evaluation (item 17), and the perspective (item 6) were missed in 21 studies (34%). Similarly, 21 studies (64%) did not specify whether they dealt with heterogeneity (item 21), as shown in Table 4.

**Discussion**

This review identified a heterogeneous body of literature on economic evaluations of different public health interventions in MENA countries, dominated by several screening programs (n=36; 59%). In addition, the number of published studies has been growing over time, particularly after 2013, and appears to be generated only in a few countries: Israel, Iran, Egypt, and Pakistan, contributing to 38 studies or 62% of the economic evaluation studies across all MENA countries. However, the number of published economic evaluation studies identified in this review remains very low and might not truly reflect the research efforts in the region. In this case, the actual number of economic evaluation studies on public health interventions might be higher in this region as studies are more likely to be written in local languages for submission to local authorities. Also, unlike economic evaluations of pharmaceutical products and vaccines, economic evaluation studies on public health interventions do not attract industry sponsorship; therefore, the chance of their publication is limited.

Consequently, this review found that the number of economic evaluation studies on public health interventions was lower than economic evaluation studies on diagnostic and therapeutic interventions (69 studies) [19] but higher than those on vaccines (46 studies) [18] in the MENA region. Besides, the low number of studies on public health intervention might be partly related to low public investment in public health interventions coupled with an industry-low interest in such interventions, considering that industry has contributed a large portion (32%) of the funding for economic evaluation studies in other regions [83]. The low number of innovative interventions in public health areas might also play a role. In addition, it could be explained by the fact that public health policy decision-making in many countries in the MENA region is not currently guided by the economic evaluation evidence and that there is a lack of region-specific data on important parameters such as epidemiological data and public health program effectiveness that could facilitate the conduct of economic evaluation studies. Furthermore, barriers to conducting economic evaluations still exist in this region. These barriers have been discussed elsewhere in previous studies [6, 18, 19, 84–86].

Moreover, several gaps were identified in this review. First is a geographical gap; there was a complete absence of economic evaluation studies from several high-income countries (i.e., Bahrain, Kuwait, Qatar, Saudi Arabia and UAE), middle-income countries (i.e., Djibouti, Iraq, Mauritania and...
| Author (references)       | Year of cost estimation | Population                                                                 | Perspective                                      | Time horizon | Discount (%) | Included costs            | Model internal validity | Double counting | Sensitivity analysis       |
|---------------------------|-------------------------|------------------------------------------------------------------------------|--------------------------------------------------|--------------|--------------|--------------------------|-------------------------|----------------|---------------------------|
| Adibi et al. [21]         | 2003                    | Premarriage individuals                                                      | Healthcare system and societal                   | 25           | 3            | Direct medical cost      | Yes                     | NA             | One-way and multivariate   |
| Al Abri et al. [22]       | 2016 to 2017            | A hypothetical cohort of 20-year-old migrants arriving in Oman               | Healthcare system                                | Lifetime     | NR           | Direct medical cost      | No                      | No             | One-way, two-way and PSA   |
| Al-Qudah et al. [23]      | 2014                    | OPD patients with general chronic diseases at Jordan university hospital     | Hospital                                         | 3 months     | NA           | Direct medical cost      | NA                      | NA             | One-way and multivariate   |
| Assanelli et al. [24]     | 2005                    | Young professional and recreational athletes                                 | NR                                               | NR           | 3            | Direct medical cost      | No                      | NA             | One-way                   |
| Balicer et al. [25]       | 2018                    | Whole population                                                            | Healthcare system and societal                   | NR           | NR           | Direct and indirect costs | NA                      | NA             | Multivariate              |
| Barfar et al. [26]        | 2019                    | Low socioeconomic women aged 35 and higher                                   | Healthcare system                                | 1            | NA           | Direct medical cost      | No                      | NA             | One-way                   |
| Carvalho et al. [27]      | 2014                    | Women aged 15–45                                                            | NR                                               | Lifetime     | NR           | Direct and indirect costs | Yes                     | NA             | One-way and PSA           |
| Chodick et al. [28]       | 2015                    | Physician and nurses aged < 45 years                                         | Employer (healthcare payer)                      | 20           | 3            | Direct medical cost      | No                      | NA             | One-way                   |
| Chodick et al. [29]       | 2016                    | Healthcare workers                                                          | Healthcare system                                | 20           | 3            | Direct costs             | No                      | No             | One-way                   |
| Chowders [30]             | 2014                    | All pregnant women                                                          | Payer                                            | 100          | 3.5          | Direct medical cost      | Yes                     | No             | Univariate and multivariate |
| Devine [31]               | 2017                    | Adult patients with vivax malaria                                            | Healthcare provider                              | 1            | NA           | Direct costs             | No                      | No             | One-way and PSA           |
| El-Dahiyat [32]           | 2016                    | The whole population                                                        | NR                                               | NR           | NR           | Product price            | NA                      | NA             | NR                        |
| El-Ghitany [33]           | 2012                    | People at intermediate and high risk scores for HCV infection               | NR                                               | NR           | NR           | Cost of testing          | No                      | NA             | NR                        |
| Eltabbakh et al. [34]     | 2015                    | Cirrhotic patients older than 18 years                                       | NR                                               | NR           | NR           | Direct medical cost      | No                      | No             | NR                        |
| Gamaoun et al. [35]       | 2010                    | Young adolescent girls (12 years) and women 35–59 years                     | NR                                               | NR           | 3            | Direct medical cost      | No                      | NA             | NR                        |
| Ginsberg et al. [36]      | 2011                    | Pregnant women, couples before marriage, relatives of subjects with thalasemia, and even school children | Healthcare system and societal                   | 30           | 5            | Direct and indirect costs | NA                      | NA             | One-way                   |
| Author (references) | Year of cost estimation | Population | Perspective | Time horizon\(^a\) | Discount (%) | Included costs | Model internal validity | Double counting | Sensitivity analysis |
|---------------------|-------------------------|------------|-------------|-------------------|--------------|----------------|------------------------|----------------|---------------------|
| Ginsberg et al. [37] | 2014                    | Females aged 12–65 years | Healthcare system | Lifetime | 3 | Direct costs | No | No | One-way |
| Ginsberg et al. [38] | 2018                    | Men who have sex with men | Societal | NR | 3 | Direct costs | No | No | One-way |
| Ginsberg et al. [39] | 2016                    | Females aged 12–65 years old | Healthcare system | 100 | 3 | Direct costs | No | No | One-way |
| Ginsberg et al. [40] | 2019                    | Adults aged 20 and above | NR | 1 | NA | Direct and indirect costs | Yes | Yes | One-way |
| Haghighat et al. [41] | 2017                    | Women aged 40–70 years | Healthcare system | 50 | 3 and 5 | Direct costs | No | No | One-way and PSA |
| Hamdani et al. [42] | 2013                    | Primary care attendees with high levels of psychological distress and functional impairment | Healthcare system | 1 | NA | Direct costs | Yes | NA | NR |
| Howard et al. [43] | 2017                    | Afghan refugee residing in Pakistan | Societal | 5 | 3 | Direct and indirect costs | No | Yes | Univariate |
| Hussain et al. [44] | 2018                    | TB patients who had been on treatment for a minimum of 2 months | Patients, health facility and TB program | 2 | 3 | Direct and indirect costs | No | No | One-way |
| Javadinasab et al. [45] | 2016                   | First-degree relatives (aged 40 years and above) of patients with colorectal cancer | Healthcare system | Lifetime | 5 | Direct medical cost | Yes | No | One-way and deterministic |
| Javanbakht [46] | 2014                    | Adults and the elderly population | Healthcare system | 20 | NR | Direct costs | Yes | NA | PSA |
| Kashi et al. [47] | 2013                    | Pregnant women | NR | Lifetime | 3 | Direct costs | No | No | PSA |
| Khneisser et al. [48] | 2010                    | All newborn babies | NR | NR | NR | Direct costs | NA | NA | NR |
| Khneisser et al. [49] | 2014                    | All male newborns | NR | NR | NR | Direct medical cost | NA | NA | NR |
| Kim et al. [50] | 2013                    | 40-year-old and asymptomatic- HCV average-risk adults in Egypt | Societal | 40 | 3 | Direct and indirect costs | Yes | Yes | One-way, two-way and PSA |
| Kim et al. [51] | 2013                    | Pre-adolescent girls (by age 9) | Societal | Lifetime | 3 | Direct and indirect costs | Yes | Yes | One-way |
| Koren et al. [52] | 2017                    | Pregnant women, husbands of affected women, and patients with β Thalassemia major | NR | 50 | NR | Direct medical cost | No | NA | NR |
| Author (references) | Year of cost estimation | Population | Perspective | Time horizon* | Discount (%) | Included costs | Model internal validity | Double counting | Sensitivity analysis |
|---------------------|-------------------------|------------|-------------|---------------|--------------|----------------|------------------------|----------------|-------------------|
| Lahiri et al. [53]  | 2014                    | The entire economically active population | Societal | 100 | 3 | Direct costs | No | NA | One-way |
| Leshno et al. [54]  | 2014                    | Average risk population (50 years and over) | NR | Lifetime | 3 | Direct costs | No | NA | One-way and two-way |
| Lim et al. [55]     | NR                      | General population and people who inject drugs | Healthcare provider | NR | 3.5 | Direct medical cost | Yes | NA | One-way |
| Lohse et al. [56]   | NR                      | Pregnant women | NR | NR | 3 | Direct costs | Yes | No | NR |
| Madaeén et al. [57] | 2012                    | Hypothetical cohort of Jordanian male smokers aged 30 years or older | Public payer (MoH) | 70 | 3 | Direct medical costs | No | NA | One-way and PSA |
| Marseille et al. [58] | 2014                   | Pregnant women | NR | Lifetime | 3 | Direct costs | No | No | One-way and multi-variate |
| Mason et al. [59]   | 2016                    | General population | NR | 10 | 3 | Direct costs | No | NA | One-way |
| Messoudi et al. [60]| 2008                    | Girls at 14 years and Women aged 30–49 | Healthcare system | Lifetime | 3 | Direct medical cost | Yes | NA | One-way and two-way |
| Mostafa et al. [61] | 2018                    | Population exposed to unsafe injection practices | Healthcare system | 30 | 3.5 | Direct medical cost | Yes | No | One-way |
| Mostafa et al. [62] | 2008                    | Population exposed to unsafe injection practices (aged 15–59 years) | Healthcare system | 26 | 3.5 | Direct medical cost | Yes | No | One-way |
| Nahvijou et al. [63]| 2012                    | Women over 15 years of age | Healthcare system | Lifetime | 3 | Direct medical costs | Yes | No | One-way |
| Okem et al. [64]    | 2013                    | Pregnant women | Payer | NR | NR | Direct medical cost | No | NA | NR |
| Ornoy et al. [65]   | NR                      | People with attention deficit hyperactivity disorder | Societal | Lifetime | NR | Direct and indirect costs | NA | NA | NR |
| Ranson et al. [66]  | 2016                    | Cohort of smokers | Public sector provider | 30–50 | 3–10 | Direct and indirect costs | No | No | NR |
| Rashidian et al. [67]| 2017                   | Iranian hospitals | Provider | 10 | 5–10 | Direct and indirect costs | No | NA | One-way |
| Rezaei-Hemami et al. [68] | 2017                 | NR | MoH | 1 | NA | Direct costs | No | NA | One-way |
| Saygili et al. [69] | 2012                    | Cancer patients receiving palliative care | Societal and patient | 1 Month | NA | Direct and indirect costs | No | NA | One-way |
| Shamshiri et al. [70]| 2016                   | 3 – 5 days old neonates | Caregiver | 82 | 3 | Direct costs | Yes | No | One-way |
| Sharma et al. [71]  | 2012                    | Women aged 25–65 years | Societal | Lifetime | 3 | Direct costs | No | NA | One-way |
| Shlomai et al. [72] | 2011                    | The whole population | MoH | 200 Days | NA | Direct and work absence costs | Yes | Yes | One-way and PSA |
| Author (references) | Year of cost estimation | Population |
|---------------------|-------------------------|------------|
| Shmueli et al. [73] | 2015                    | Moderate-to-heavy smokers aged 45 years or older |
| Sladkevicius et al. [74] | 2016                | Neonates |
| Verguet et al. [75] | 2019                    | Heterosexual adult population (15–49-year-old) |
| Vijayaraghavan et al. [76] | 2008               | 12 million children aged six months to 12 years and 5 million children aged 9 to 59 months |
| Vijayaraghavan et al. [77] | 2010               | Children and women of childbearing age in populations not reached by routine health services in a conflict setting |
| Wilcox et al. [78] | 2013                    | Whole population |
| Yarahmadi et al. [79] | 2010                 | Newborn babies |
| Yosefy et al. [80] | 2018                    | Adults aged 25–64 years |
| Yosefy et al. [81] | 2017                    | All hypertensive patients |

| Perspective | Time horizon* | Discount (%) | Included costs | Model internal validity | Double counting | Sensitivity analysis |
|-------------|---------------|--------------|----------------|-------------------------|-----------------|---------------------|
| Healthcare system | Lifetime | 3 | Direct medical cost | Yes | No | One-way and PSA |
| Societal | Lifetime | 3 | Direct and indirect costs | No | NA | One-way and PSA |
| NR | 5 | NR | Direct medical cost | No | No | One-way |
| Donor | 10 | 3 | Direct costs | Yes | NA | One-way |
| Donor | 2 | NR | Direct medical costs | No | NA | One-way |
| Healthcare system | 10 | 3 | Direct costs | Yes | NA | Multi-way |
| NR | 70 | 3 | Direct medical costs | NA | NA | NR |
| NR | 20 | 3 | Direct costs | No | No | One-way |
| NR | 10 | 4 | Direct costs | No | No | One-way |

OPD out-patient department, HCV hepatitis C virus, PSA probabilistic sensitivity analysis, MoH Ministry of Health, NA not applicable, NR not reported, TB tuberculosis

* In years unless otherwise stated
| **Author (references)** | **Source of cost data** | **Source of epidemiological data** | **Source of effectiveness data** | **Source of utility data** | **Source of funding** | **Threshold** | **ICER and results** | **Conclusion** |
|-------------------------|-------------------------|------------------------------------|---------------------------------|--------------------------|---------------------|---------------|---------------------|----------------|
| Adibi et al. [21]       | Iranian                 | Iranian, international and expert consensus | International                   | NA                       | Academia            | 1 GDP (US$ 1790 in 2003) | The cost/CHB infection averted was US$ 202 and 197 for the strategies 1 and 2, respectively | Premarriage prevention of HBV transmission in Iran seems cost saving |
| Al Abri et al. [22]     | Omani and international | Omani and international            | International                   | International            | Industry            | WTP of US$ 100,000 in 2020 | The QFT-Plus with 3HP was more cost-effective than the other TB strategies with an ICER of US$ 2915/QALY gained. The CXR strategy was the least cost-effective | IGRA testing followed by 3HP is the most cost-effective intervention |
| Al-Qudah et al. [23]    | Jordanian and assumption | Jordanian                          | International                   | NA                       | None                | None                      | Benefit-to-cost ratio was 5.98 and an annual net benefit was US$ 64,393 | Clinical pharmacist intervention is cost beneficial and offers substantial cost savings to the healthcare payer |
| Assanelli et al. [24]   | Algerian                | International                       | International                   | NA                       | Industry            | NR                        | The total cost in Algeria was $PPP 79,395, total cost/athlete was $PPP 74.10, and CER of screening was $PPP 582 | Results strongly support the utilization of 12-lead ECG in the pre participation screening of young athletes |
| Balicer et al. [25]     | Local                   | International                       | International                   | NA                       | NR                  | NA                        | Therapeutic treatment and postexposure prophylaxis were shown to be cost-saving, with a cost–benefit ratio of 2.44–3.68 | Pre pandemic stockpiling of Oseltamivir is cost-saving to the economy and to the healthcare system, if the use is limited to treat patients at high risk |
| Barfar et al. [26]      | Iranian                 | Iranian                            | International                   | NA                       | Government          | NR                        | ICER/breast cancer detected was US$ 15,742 | Mammography screening program is not cost-effective |
| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|---------------------|---------------------|-------------------------------|----------------------------|-----------------------|------------------|----------|----------------|------------|
| Carvalho et al. [27] | WHO-CHOICE, donors and local | Afghan and international | NR | NA | NGO | 1–3 GDP/C (US$ 500–1500 in 2009/10) | ICERs of family planning strategies were below US$ 130/LYG. ICERs of stepwise improvements in maternal health services were below US$ 200/LYG. | The combination of investment in reproductive health infrastructure and increase in family planning is highly cost-effective. |
| Chodick et al. [28] | Local and international | Local | International | NA | NR | NR | The incremental cost of screening and vaccination of susceptible workers was US$ 23,713/avoided case, serological tests was US$ 206,692/avoided case, and vaccinating all HCWs without serotesting was US$ 10.4 million/avoided case. | Screening and vaccination of susceptible workers using anamnestic selection are cost-effective while screening alone and mass vaccination alone of all HCWs without serotesting are not cost-effective. |
| Chodick et al. [29] | Local and international | Local and international | International | International | Government | US$ 60,000 | Screening prior vaccination among 18- to 39-year-old physicians and paramedical workers achieved the lowest cost per prevented Hepatitis A case (US$ 6240 and 6773, respectively). ICERs/QALY were US$ 56,532 and 61,350 for the same groups. | Screening followed by selective vaccination for physicians and for paramedical workers is recommended. |
| Chowers [30] | Local | Local and international | International | Local and international | NR | 1–3 GDP/C (US$ 28,667–86,000 in 2014) | Universal prenatal screening dominates over the current policy with an ICER of (US$ -11,546)/QALY gained | Universal prenatal HIV screening is projected to be cost saving. |
Table 3 (continued)

| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|---------------------|---------------------|-------------------------------|------------------------------|-----------------------|-------------------|----------|-----------------|------------|
| Devine [31]         | International       | International                 | International              | International         | Government, academia and NGO | 1 GDP/C | The ICERs were US$ 18.6 for 14-day Primaquine (without G6PD screening), US$ 1089 for Tafenoquine in male and 7-day Primaquine in female (both with G6PD screening) | Using a gender-based treatment strategy could significantly change the landscape for providing the radical cure of Plasmodium vivax Malaria |
| El-Dahiyat [32]      | Jordanian           | NA                            | NA                          | NA                    | None               | NA       | The average savings if using the generic drugs instead of the originator brand medicines in Jordan was 32.68%, and the maximum savings was 74.29% | Generic substitution can provide significant savings to patients and healthcare system |
| El-Ghitany [33]      | Egyptian            | Egyptian                      | NR                          | NA                    | None               | NR       | Using EGCRISC would save LE 0.43 billion accounting for about 21,646,227 unnecessary tests | EGCRISC is a cost-effective tool that must be adopted nationwide |
| Eltabbakh et al. [34] | Egyptian            | NR                            | International              | NR                    | 1–3 GDP/C (US$ 3184–9553) | | ICER was not reported. The costs were US$ 1105 and 1180/QALY for screening with ultrasound only and for both ultrasound and alpha-fetoprotein, respectively | Screening for HCC is highly cost-effective |
Table 3 (continued)

| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|----------------------|---------------------|--------------------------------|-----------------------------|-----------------------|------------------|----------|------------------|------------|
| Gamaoun et al. [35]  | Tunisian, interna-  | Tunisian and international    | Tunisian and international  | NA                    | NR               | NR       | The incremental  | Cervical cancer screening each  |
|                      | tional and estima-  |                                |                             |                       |                  |          | cost of cervical  | 5 years combined with scheduled |
|                      | tions               |                                |                             |                       |                  |          | cancer screening  | two-dose anti-HPV               |
|                      |                     |                                |                             |                       |                  |          | according to     | national vaccination             |
|                      |                     |                                |                             |                       |                  |          | 10-year periodic- | program is the               |
|                      |                     |                                |                             |                       |                  |          | ity was US$ 8219,| best cost-effective             |
|                      |                     |                                |                             |                       |                  |          | 5-year periodic- | strategy for cervical          |
|                      |                     |                                |                             |                       |                  |          | ity was US$ 14,567| cancer prevention             |
|                      |                     |                                |                             |                       |                  |          | 3-year periodic- |                         |
|                      |                     |                                |                             |                       |                  |          | ity was US$ 20,479|                         |
|                      |                     |                                |                             |                       |                  |          | and finally the  |                         |
|                      |                     |                                |                             |                       |                  |          | national vaccina- |                         |
|                      |                     |                                |                             |                       |                  |          | tion program was |                         |
|                      |                     |                                |                             |                       |                  |          | US$ 36,854 per   |                         |
|                      |                     |                                |                             |                       |                  |          | avoided cervical  |                         |
|                      |                     |                                |                             |                       |                  |          | cancer case      |                         |
| Ginsberg et al. [36] | Local and assump-  | Local                          | Local and international    | NA                    | NR               | NR       | The benefit–cost | The monetary benefits of a     |
|                      | tions               |                                |                             |                       |                  |          | ratio of the     | nationwide thalassemia         |
|                      |                     |                                |                             |                       |                  |          | program to the   | screening program to society   |
|                      |                     |                                |                             |                       |                  |          | health services  | and to the healthcare system   |
|                      |                     |                                |                             |                       |                  |          | was 4.22:1 which | exceeds the program's costs    |
|                      |                     |                                |                             |                       |                  |          | increased to 6.01:1 when a |                         |
|                      |                     |                                |                             |                       |                  |          | societal perspec- |                         |
|                      |                     |                                |                             |                       |                  |          | tive was taken   |                         |

The incremental cost of cervical cancer screening according to 10-year periodicity was US$ 8219, 5-year periodicity was US$ 14,567, 3-year periodicity was US$ 20,479, and finally the national vaccination program was US$ 36,854 per avoided cervical cancer case.
Table 3 (continued)

| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|---------------------|---------------------|-------------------------------|-----------------------------|-----------------------|-------------------|----------|------------------|------------|
| Ginsberg et al. [37] | Local               | Local and international       | International               | International         | NR                | 1–3 GNP/C (US$ 27,055–81,165 in 2010) | ICER/DALY averted was US$ 2509 for Pap smear screening of females at age 40, US$ 10,543 for thrice a lifetime VIA, US$ 22,841 for three doses HPV vaccination at age 12 plus a booster dose at ages 32 and 52 combined with penta-annual Pap smear screening for females aged 20–65, and US$ 30,029 for addition of penta-annual HPV DNA screening to vaccination and penta-annual Pap smear | HPV screening interventions combined with vaccination program have the potential to be very cost-effective |
| Ginsberg et al. [38] | Local               | Local                         | International               | International         | None              | 1–3 GDP/C (US$ 40,439–121,316 in 2017) | ICER of HIV pre-exposure prophylaxis drugs was around US$ 967,744/averted DALY | HIV pre-exposure prophylaxis drugs were found not to be cost-effective. Prices would have to fall by 90.7% for the intervention to become cost-effective |
| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|---------------------|---------------------|-------------------------------|-----------------------------|-----------------------|------------------|-----------|----------------|------------|
| Ginsberg et al. [39] | Local and international | Local                          | International               | NR                    | NR               | 1–3 GDP/C (US$ 20,366–61,098 in 2007) | ICER/QALY gained were US$ 65,024 for annual Pap smear, US$ 35,403 for tri-annual Pap smears, US$ 28,612 for penta-annual Pap smears, US$ 9,273 for thrice a lifetime Pap smears, US$ 48,660 for tri-annual Pap smears with HPV-DNA testing, US$ 33,705 for penta-annual combination, US$ 46,807 for a thrice a lifetime HPV-DNA testing, US$ 61,264 for thrice a lifetime VIA, US$ 81,404 for one-off HPV vaccination females aged 12, US$ 272,010 for vaccinating females every 10 years from age 12 to 62 | All HPV screening interventions are cost effective or highly cost-effective except for annual Pap smear and a thrice a lifetime VIA. HPV vaccination program is not cost-effective as well |
| Ginsberg et al. [40] | Local and international | Local                          | NA                          | NR                    | NR               | 1–3 GNP/C (NIS 104,161–312,483 in 2010) | Implementation of the cluster of interventions would save 32671 QALYs at a cost of NIS 47,558/QALY | Fielding an eight-pronged combined clinical and community-based dietary interventional program is very cost-effective |
| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|---------------------|---------------------|-------------------------------|-------------------------------|------------------------|------------------|-----------|-----------------|------------|
| Haghighat et al. [41] | Iranian | Iranian and international | Iranian | International | None | 1–3 GDP/C (Int. $13,100–39,300 in 2012) | ICERs of mammography screening were Int. $37,350, Int. $141,641 and Int. $389,148/QALY gained in the first, second and third rounds of screening program, respectively | Mammography screening program is cost effective in 53% of the cases, but ICER/QALY in the second and third rounds of screening are not cost-effective |
| Hamdani et al. [42] | Pakistani | Pakistani | Pakistani | NA | Government | US$ 67 | The mean ICER to successfully treat a case of depression using an international supervisor was US$517 compared with US$102.93 using a local one | The Problem Management + is more effective but also more costly |
| Howard et al. [43] | Pakistani | Pakistani and international | NR | Afghan | None | 1–3 GDP/C (US$479–1436 in 2015) | The additional cost of including indoor residual spraying over five years per case prevented was US$39 (50 for Vivax and 182 for Falciparum). Per DALY averted this was US$266 | Adding indoor residual spraying is cost-effective |
| Hussain et al. [44] | Pakistani | NR | International | International | NGO | NR | Incentive-based active case finding program costs US$223 per patient treated and incrementally averted 0.17 DALYs at the cost of US$15.74 over 6 months | Both screening strategies appear to be cost-effective in an urban Pakistani context |
| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|---------------------|---------------------|--------------------------------|-----------------------------|-----------------------|-------------------|-----------|------------------|------------|
| Javadinasab et al.  [45] | Iranian | Iranian and international | Iranian and international | International | NR | 1–3 GDP/C (US$ 5442–16,326 in 2014) | In CUA, compared with no screening, the ICERs/QALY gained were US$ 489 for one screening/lifetime at age 50, US$ 709 for one screening/lifetime at age 55, US$ 1010 for screening every 10 years starting at age 50, US$ 1386 for screening every 10 years starting at age 40, US$ 2310 for screening every 5 years starting at age 50 and US$ 3135 for screening every 5 years starting at the age of 40. In CEA, compared with no screening, the ICERs/LYG gained were US$ 725 for one screening/lifetime at age 50, US$ 1115 for one screening/lifetime at age 55, US$ 1540 for screening every 10 years starting at age 50, US$ 1995 for screening every 10 years starting at age 40, US$ 3508 for screening every 5 years starting at age 50, and US$ 4489 for screening every 5 years starting at the age of 40. | Colorectal cancer colonoscopy screening in high-risk individuals is cost-effective in Iran. Colonoscopy screening every 10 years starting at the age of 40 is the most cost-effective strategy. |
| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold ICER and results | Conclusion |
|---------------------|--------------------|--------------------------------|-----------------------------|----------------------|------------------|--------------------------|------------|
| Javanbakht [46]     | Iranian            | Iranian and international     | NA                          | Academia             | NR               | The estimated savings in health cost per capita were US$ 0.43, 8.42, 39.97 and 190.25 in 1, 5, 10 and 20-years’ time horizons, respectively. Corresponding total aggregated avoidable costs for entire population were US$ 33.83 million, 661.31 million, 3138.21 million and 14,934.63 million, respectively. Increasing dairy foods consumption to recommended levels would be associated with reductions in healthcare costs. |           |
| Kashi et al. [47]   | Estimation         | International                 | International              | NGO                  | 1–3 GDP/C        | The ICER of transitioning from iron and folic acid supplementation to multiple micronutrient supplementation was US$ 41.54/DALY in Pakistan. Multiple micronutrient supplementation is cost-effective and generates positive health outcomes for both infants and pregnant women. |           |
| Khneisser et al. [48]| Lebanese           | Lebanese                      | NR                          | Academia             | NA               | A reduction by half of direct cost of care, reaching an average US$ 31,631 per detected case was shown. This difference more than covers the expense of starting a newborn screening program. Direct and indirect costs saved through early detection of these disorders are important enough to justify universal publicly-funded screening, especially in developing countries with high consanguinity rates. |           |
| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|---------------------|---------------------|--------------------------------|-----------------------------|-----------------------|-------------------|----------|-----------------|------------|
| Khneisser et al. [49] | Lebanese | Lebanese | NR | NA | Academia | NA | The cost–benefit index of systematic screening was about 2.58 times lower than that of anemia-related hospitalizations in an unscreened population | The efficiency of routinely testing described in this study supports changes in screening policies for boys |
| Kim et al. [50] | Egyptian | Egyptian and international | Egyptian and international | International | Academia | 1–3 GDP/C (US$ 3333–10,000 in 2014) | No screening would cost US$ 1840 for 19.179 QALYs. Implementing a screening program using triple-therapy was dominant compared to no screening because it would have lower total costs (US$ 1816) and lead to higher QALYs (19.229) | Screening and treatment programs for HCV in Egypt can be cost-effective methods to reduce the burden of liver disease |
| Kim et al. [51] | Local, regional and assumption | Local and international | Local and international | International | NGO and public | 1 GDP/C (Int. $ 7521 in Algeria, 12,605 in Lebanon and 12,540 in Turkey; all in 2010 values) | Cytology-based screening alone was less cost effective, in Lebanon, Turkey and Algeria. The CER for combined vaccination and cytology screening was Int. $ 7520 in Algeria and 12,540 in Turkey while it was not cost-effective in Lebanon | Annual cytology screening is not cost-effective. Promoting organized, less frequent (3–5 years) screening and adopting HPV DNA testing can result in more efficient cervical cancer prevention efforts |
| Koren et al. [52] | Local | Local | NR | NA | Industry | NR | The cost of preventing one affected newborn was US$ 63,660 compared to 1,971,380 for treatment of a patient during 50 years | Implementation of a national β Thalassemia prevention program appears cost-effective |
### Table 3 (continued)

| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|---------------------|---------------------|--------------------------------|-----------------------------|-----------------------|-------------------|-----------|------------------|------------|
| Lahiri et al. [53]  | Local, regional and assumptions | International | International | NA | NGO | NR | In all of the sub-regions, training was the most cost-effective with CER of US$ 74 per LYG in the sub-region comprising of Egypt, Iraq, Morocco and Yemen so it would be the first choice option where resources are scarce. | Worker training is a low cost and feasible first step toward reducing back pain/injury incidence. However, the engineering controls interventions as well as the full ergonomics program look very cost effective for all of the WHO sub-regions |
| Leshno et al. [54]  | Local | Local, international and estimations | International | NA | Industry | NR | Annual FOBT plus sigmoidoscopy during a 5-year interval was the best strategy with an ICER of NIS 1268/LYG | It is highly cost-effective to screen average-risk asymptomatic individuals beginning at age 50. One-time colonoscopic screening or FOBT plus sigmoidoscopy would be the preferred options |
| Lim et al. [55]     | Pakistani, international and assumption | Pakistani and international | NR | NA | NGO | NR | Screening and treatment strategy will cost US$ 3.9 billion over 13 years with the yearly costs making up 9% of the annual health budget of Pakistan. This translates to about US$ 600/cure. | Pakistan needs to invest up to 9% of its yearly health expenditure (0.11% of its GDP or approximately US$ 1.30/person/year) to achieve the WHO HCV-elimination target |
| Lohse et al. [56]   | Local | International | International | NR | Industry | 1 GDP/C (US$ 29,500 in 2010) | The full costs of universal screening of pregnant women was US$ 5887/DALY | GDM-screening and postpartum lifestyle management have an attractive cost-effectiveness ratio |
| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|---------------------|---------------------|-------------------------------|----------------------------|-----------------------|------------------|-----------|-----------------|------------|
| Madae’en et al. [57] | Jordanian           | Jordanian                     | International              | NA                    | None              | 1–3 GDP/C (US$4395–13,185 in 2019) | 103,970 and 64,030 life years were gained using the Varenicline and NRT regimen compared to the no-intervention arm. The costs per LYG were US$1696 and US$1890 for Varenicline and NRT, respectively | Provision of Varenicline is a cost-effective intervention. Also, provision of NRT is likely to be cost-effective |
| Marseille et al. [58] | Local, international and assumptions | Local, international and estimations | International | International | Industry | 1–3 GDP/C (US$29,800–89,400 in 2010) | The program cost/1000 pregnant women was US$259,929. The cost/DALY averted was US$1830 | By WHO standards, GDM interventions are highly cost-effective |
| Mason et al. [59] | Local (from each country) | NR | International | NA | Academia and NGOs | NR | In all four countries most policies were cost saving compared with the baseline. The combination of all three policies resulted in estimated cost savings of US$235,000,000 and 6455 LYG in Tunisia; US$39,000,000 and 31,674 LYG in Syria; US$6,000,000 and 2682 LYG in Palestine and US$1,300,000,000 and 378,439 LYG in Turkey | Reducing dietary salt intake will reduce CHD deaths in the four countries. Having a comprehensive health education strategy and food industry procedures for labeling and minimizing salt content would save money and lives |
| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|---------------------|---------------------|-------------------------------|-----------------------------|-----------------------|-------------------|----------|------------------|------------|
| Messoudi et al. [60] | Moroccan, regional and international | Moroccan | International | NA | Government, academia, NGO and industry | 1–3 GDP/C (US$ 2860–8580 in 2018) | The costs were US$ 551/LYS for current VIA screening and US$ 1150/LYS for HPV vaccination of pre-adolescent girls compared to no intervention. The cost of combined strategy of HPV vaccination and current screening was US$ 2843/LYS compared to screening alone | Current screening would be good value for money compared with no intervention but would be inefficient compared with vaccination |
| Mostafa et al. [61] | Egyptian | Egyptian | International | International | NGO | NR | Using Safety-engineered syringes was dominant option (less costly and more effective) with an ICER of Int.$ − 1802/QALY gained compared to conventional syringes | Using Safety-engineered syringes is more effective and cost-saving strategy |
| Mostafa et al. [62] | Egyptian | Egyptian and international | NR | International | NGO | NR | Using Safety-engineered syringes was dominant option (less costly and more effective) with an ICER of Int. $ − 18,650/QALY gained compared to conventional syringes | Using Safety-engineered syringes is cost saving prevention policy |
| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|--------------------|---------------------|--------------------------------|-----------------------------|------------------------|-------------------|-----------|-----------------|------------|
| Nahviouj et al. [63] | Iranian and assump-tions | Iranian and interna-tional | Iranian and interna-tional | International | Academia | $1–2 GDP/C (US$ 6631–13,262 in 2013) | Compared with no-screening strategy, the most cost-effective strategy (ICER of US$ 8875/QALY) was HPV DNA testing beginning at age 35 years with 10-year screening intervals | Organized cervical screening with HPV DNA testing for women is recommended, beginning at age 35 and repeated every 10 or 5 years |
| Okem et al. [64] | Turkish | Turkish | International | NA | NR | NR | ICER of NIPT was PPP 17,235,174/Down syndrome cases detected compared to combined test. ICER of NIPT following combined test was PPP 6,873,082/Down syndrome cases detected compared to combined test | NIPT leads to very high costs despite its high effectiveness. Thus, cost of NIPT should be decreased |
| Ormooy et al. [65] | Local and assump-tions | Local | NA | NA | None | NA | The benefit cost ratio was 7.02 and, assuming only 50% success of treatment, it was 3.51 | National screening program offers a very high cost benefit ratio |
| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|---------------------|---------------------|-------------------------------|----------------------------|-----------------------|------------------|-----------|------------------|------------|
| Ranson et al. [66]  | Local, regional and international | Local, regional and international | Local, regional and international | NR | NGO | NR | Tax increases to raise the real price of cigarettes by 10% worldwide would prevent between 5 and 16 million tobacco-related deaths, and could cost US$ 3–70/DALY saved in LMIC. NRT and a package of non-price interventions other than NRT were also cost-effective in LMIC, at US$ 280–870 and US$ 36–710/DALY, respectively. In HIC, price increases were found to have a cost-effectiveness of US$ 83–2771/DALY, NRT US$ 750–7206/DALY and other non-price interventions US$ 696–13,924/DALY. | Tobacco control policies, particularly tax increases on cigarettes, are cost-effective relative to other health interventions |
| Rashidian et al. [67] | Iranian International | National | NA | Government | NR | Caspian-Alborz device was the most cost-effective alternative with an average cost-effectiveness from US$ 33 to 333/treatment of every one cubic meter of infectious waste in various conditions | There is more than one cost-effective device for different conditions and times in a country |
| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|---------------------|---------------------|-------------------------------|-----------------------------|-----------------------|------------------|----------|----------------|------------|
| Rezaei-Hemami et al. [68] | Iranian | Iranian and international | Iranian and international | NA | Academia | NR | The most cost-effective interventions were the use of insecticide-treated nets, Larviciding, surveillance for diagnosis and treatment of patients in less than 24 h, and indoor residual spraying, respectively | Insecticide-treated net is the most cost-effective intervention |
| Saygili et al. [69] | Turkish | Local and international | NR | NA | NR | NR | From a societal perspective, palliative care services provided at hospital IPD were more cost-effective. From a patient perspective, home healthcare was more cost-effective with an ICER of US$ 33.43 and US$ -18.30/QALY compared to hospital IPD and comprehensive palliative care center, respectively | Hospital inpatient palliative care is more cost-effective compared with other alternatives from societal perspective |
| Shamshiri et al. [70] | Iranian | Iranian | NR | Iranian | Academia | NR | ICERs for screening programs with different TSH cut-off points versus no screening were similar (US$ – 4.5 ± 0.2/DALY) | The current threshold of TSH in the national congenital hypothyroidism screening program is the most cost-effective threshold |
| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|---------------------|---------------------|--------------------------------|-----------------------------|-----------------------|-------------------|-----------|-----------------|------------|
| Sharma et al. [71]  | Lebanese and international | Lebanese | International | NA | None | 1 GDP/C (Int. $17,462 in 2014) | ICERs/LYG were Int. $80,670 for annual cytologic screening at 20% coverage, Int. $12,210 for HPV DNA testing screening every 5 years at 50% coverage and Int. $16,340 for HPV DNA testing every 4 years at 50% coverage | Screening each 5 and 4 years is cost effective but annually is not |
| Shlomai et al. [72] | NR | Local | NA | NR | None | WTP of US$ 50,000–150,000 | The ICER would be US$ 45.1 million/one death case prevented and US$ 15.24 million/QALY | A national lockdown strategy has a moderate advantage in saving lives with extremely high costs and possible overwhelming economic effects |
| Shmueli et al. [73] | Local | Local | International | Local | NGO and academia | WTP of US$ 10,000 and 20,000 | ICER/QALY gained by screening was US$ 1464 | Screening presents a good value for the money and should be considered for inclusion in the national list of health services financed publicly |
| Sladkevicius et al. [74] | Libyan | National, regional and international | International | NA | Industry | WTP of US$ 4,000 | The expected cost undiscounted LYG was US$ –15,500. There would be a 90% return on investment in the screening program since society would gain US$ 1.9 for every invested US$ 1 | Screening program is cost-effective from a societal perspective |
| Author (references)      | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results                                                                                           | Conclusion                                                                                       |
|--------------------------|---------------------|--------------------------------|------------------------------|------------------------|-------------------|-----------|-----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| Verguet et al. [75]      | Regional and international | International | International | International | NR                | 1–3 GDP/C | ICERs/DALY were US$ 12,300 in Djibouti, 41,000 in Mauritania, 41,600 in Somalia and 19,600 in Sudan     | Adding HIV pre-exposure prophylaxis is not cost-effective in Djibouti, Mauritania, Somalia, and Sudan due to low levels of HIV burden and high levels of male circumcision |
|                          |                     |                                |                              |                        |                   |           |                                                                                                           |                                                                                                  |
| Vijayaraghavan et al. [76]| National and international | National and international | International | NA           | NR                | 1–3 GNI/C (US$ 735–2205 in 2002) | The cost/death prevented was US$ 23.6. For every one million US$ invested by donors, an estimated 42,300 deaths were prevented by the campaigns. For the same investment, the catch-up campaign averted 43,700 deaths while the follow-up campaign averted 38,300 deaths | The campaigns were extremely cost-effective and provided excellent returns on investment under all scenarios considered in the analysis |
|                          |                     |                                |                              |                        |                   |           |                                                                                                           |                                                                                                  |
| Vijayaraghavan et al. [77]| Somali              | International | International | NA           | Donors            | 1 GNI/C (US$ 140 in 2010) | The cost-effectiveness ratios were US$ 44/LYS by 1st round, US$ 280/LYS by 2nd round and US$ 34/LYS by both rounds combined. For every US$ 1 million invested in both rounds, an estimated 615 children’s lives, or 29,500 life years, were saved | Child Health Days are very cost-effective strategy for addressing the leading causes of children mortality in a conflict setting like Somalia |
### Table 3 (continued)

| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|---------------------|---------------------|--------------------------------|-----------------------------|-----------------------|-------------------|----------|-----------------|------------|
| Wilcox et al. [78]  | Syrian              | Syrian                         | International               | NA                    | Academia          | PPP$ 13,000–38,997 | CERs/LYG were PPP$ 5453 for reformulation of salt content within packaged foods, PPP$ 2201 for combination of health promotion campaign and reformulation of salt content and PPP$ 2125 for combination of reformulation of salt content and labeling of salt content on packaged foods | All salt reduction policies are cost-saving or cost effective |
| Yarahmadi et al. [79] | NR                | Local                          | International               | NA                    | NR                | NR       | Benefit to cost ratios with regard to education and care of patients with mental retardation were lower by 22 times (100% in the public sector), 41 times (100% in the private sector), 32 times (50% in the public sector and 50% in the private sector), 34 times (100% in the public sector day and night), 47 times (50% in the public sector and 50% in the private sector day and night), and 60 times (100% in the private sector day and night) | Newborn screening program for congenital hypothyroidism has been quite effective |
Table 3 (continued)

| Author (references) | Source of cost data | Source of epidemiological data | Source of effectiveness data | Source of utility data | Source of funding | Threshold | ICER and results | Conclusion |
|----------------------|---------------------|--------------------------------|-----------------------------|-----------------------|------------------|----------|-----------------|------------|
| Yosefy et al. [80]   | Local               | Local and International       | NR                          | Local                 | NR               | 1–3 GDP/C (US$ 16,497–49,491 in 2003) | The implementation of health education program nationwide was likely to save over 2000 lives and US$ 185 million in health care resources alone. | It is conceivable that the health education program may be extended not only throughout this country, but also to neighboring countries. |
| Yosefy et al. [81]   | Local               | NR                             | Local                       | International         | Government      | NR       | The net saving to health services would be US$ 977,993 and the increase in QALYs would be 602 years. | Better control of hypertensive patients is cost-effective. |

3HP 3 months of weekly rifapentine 900 mg plus isoniazid 900 mg, HBcAb hepatitis B core antibody, HBsAg hepatitis B surface antigen, CBA cost–benefit analysis, CEA cost-effectiveness analysis, CER cost-effectiveness ratio, CHB chronic hepatitis B, CHD coronary heart disease, CMA cost-minimization analysis, CUA cost-utility analysis, CVDs cardiovascular diseases, CXR chest X-ray, DALYs disability adjusted life years, DM diabetes mellitus, ECG electrocardiogram, EGOXISC Egyptian hepatitis C virus risk score screening tool, FOBT fecal occult blood test, G6PD glucose-6-phosphate dehydrogenase, GDM gestational diabetes mellitus, GDP/C gross domestic product per capita, GNI/C gross national income per capita, HBV hepatitis B virus, HCC hepatocellular carcinoma, HCV hepatitis C virus, HCWs healthcare workers, HIC high income countries, HIV human immunodeficiency virus, HPV human papillomavirus, HPV-DNA human papillomavirus DNA assay, ICER incremental cost-effectiveness ratio, IGRA interferon gamma release assay, Int. $ international dollar, IED inpatient department, LE Egyptian pound, LMIC low and middle income countries, LYG life years gained, LYS life years saved, NA not applicable, NCDs noncommunicable diseases, NGO non-governmental organization (non-for-profit), NIFT non-invasive prenatal testing, NS New Israeli Shekels, NR not reported, NRT nicotine replacement therapy, Pap-smear Papanicolaou test, QALYs quality-adjusted life years, QFT-Plus QuantiFERON-TB gold plus, SR Saudi Riyal, TST tuberculin skin test, VIA visual inspection with acetic acid, WHO World Health Organization, WHO-CHOICE World Health Organization-CHOosing Interventions that are Cost-Effective, WTP willingness-to-pay.
### Table 4  Study quality assessment by CHEERS checklist

| Author (References) | Title | Abstract | Introduction | Population Setting/location | Perspective | Comparators | Time horizon | Discount rate | Outcome measures | Effectiveness | Preference based Outcomes |
|---------------------|-------|----------|--------------|-----------------------------|-------------|-------------|--------------|--------------|------------------|-------------|--------------------------|
| Adibi et al. [21]   |       |          |              |                             | +           | +           | +            | +            | +                | +           | +                        |
| Al Abri et al. [22] |       |          |              |                             | +           | −           | +            | +            | +                | +           | +                        |
| Al-Qudah et al. [23]|       |          |              |                             | +           | +           | +            | +            | +                | NA          | −                        |
| Assanielli et al. [24]|     |          |              |                             | +           | +           | +            | −            | −                | +           | +                        |
| Baicir et al. [25]  |       |          |              |                             | +           | +           | +            | −            | +                | +           | NA                       |
| Barfar et al. [26]  |       |          |              |                             | +           | +           | +            | +            | +                | +           | +                        |
| Carvalho et al. [27]|       |          |              |                             | +           | +           | +            | −            | +                | −           | −                        |
| Chodick et al. [28] |       |          |              |                             | +           | +           | +            | +            | +                | +           | +                        |
| Chodick et al. [29] |       |          |              |                             | +           | +           | +            | +            | +                | −           | +                        |
| Chowers [30]        |       |          |              |                             | +           | +           | +            | +            | −                | −           | −                        |
| Devine [31]         |       |          |              |                             | +           | +           | +            | +            | +                | −           | −                        |
| El-Dahiyat [32]     |       |          |              |                             | +           | +           | +            | +            | +                | −           | −                        |
| El-Ghitany [33]     |       |          |              |                             | +           | +           | +            | −            | +                | −           | −                        |
| Eltabbakh et al. [34]|     |          |              |                             | +           | +           | +            | −            | +                | +           | +                        |
| Gamaoun et al. [35] |       |          |              |                             | +           | +           | +            | −            | +                | −           | −                        |
| Ginsberg et al. [36]|       |          |              |                             | +           | +           | +            | +            | +                | −           | −                        |
| Ginsberg et al. [37]|       |          |              |                             | +           | +           | +            | +            | +                | −           | −                        |
| Ginsberg et al. [38]|       |          |              |                             | +           | +           | +            | +            | +                | +           | +                        |
| Ginsberg et al. [39]|       |          |              |                             | +           | +           | +            | +            | +                | +           | +                        |
| Ginsberg et al. [40]|       |          |              |                             | +           | +           | +            | −            | +                | +           | +                        |
| Haghhighat et al. [41]|     |          |              |                             | +           | +           | +            | +            | +                | +           | +                        |
| Hoeff et al. [42]   |       |          |              |                             | +           | +           | +            | +            | +                | −           | +                        |
| Hussain et al. [44] |       |          |              |                             | +           | +           | +            | +            | +                | +           | +                        |
| Javadinasab et al. [45]|     |          |              |                             | +           | +           | +            | +            | +                | −           | −                        |
| Javabakht [46]      |       |          |              |                             | +           | +           | +            | +            | +                | −           | −                        |
| Kashiet al. [47]    |       |          |              |                             | +           | +           | +            | −            | +                | +           | +                        |
| Khneisser et al. [48]|     |          |              |                             | +           | +           | +            | −            | +                | −           | −                        |
| Khneisser et al. [49]|       |          |              |                             | +           | +           | +            | −            | +                | −           | −                        |
| Kim et al. [50]     |       |          |              |                             | +           | +           | +            | +            | +                | +           | +                        |
| Kim et al. [51]     |       |          |              |                             | +           | +           | +            | +            | +                | +           | +                        |
| Koren et al. [52]   |       |          |              |                             | +           | +           | +            | −            | +                | −           | −                        |
| Lahiri et al. [53]  |       |          |              |                             | +           | +           | +            | +            | +                | +           | −                        |
| Lesnno et al. [54]  |       |          |              |                             | +           | +           | +            | +            | +                | +           | +                        |
| Lim et al. [55]     |       |          |              |                             | +           | +           | +            | −            | +                | −           | −                        |
Table 4 (continued)

| Author (References) | Title | Abstract | Introduction | Population Setting/location | Perspective | Comparators | Time horizon | Discount rate | Outcome measures | Effectiveness based | Preference Outcomes |
|---------------------|-------|----------|--------------|-----------------------------|-------------|-------------|--------------|---------------|-------------------|---------------------|---------------------|
| Lohse et al. [56]   |       |          |              |                             |             |             |              |               | +                 | +                   | −                   | +                   |
| Madaeën et al. [57] |       |          |              |                             |             |             |              |               | +                 | +                   | +                   | NA                  |
| Marseille et al. [58]|       |          |              |                             |             |             |              |               | +                 | −                   | +                   | +                   |
| Mason et al. [59]   |       |          |              |                             |             |             |              |               | +                 | +                   | −                   | +                   |
| Messoudi et al. [60]|       |          |              |                             |             |             |              |               | +                 | +                   | +                   | NA                  |
| Mostafa et al. [61] |       |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |
| Mostafa et al. [62] |       |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |
| Nalvi Jain et al. [63]|      |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |
| Okem et al. [64]    |       |          |              |                             |             |             |              |               | +                 | +                   | +                   | NA                  |
| Omoj et al. [65]    |       |          |              |                             |             |             |              |               | +                 | +                   | +                   | NA                  |
| Ranson et al. [66]  |       |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |
| Rashidian et al. [67]|      |          |              |                             |             |             |              |               | +                 | +                   | +                   | NA                  |
| Rezaei-Hemami et al. [68]|   |          |              |                             |             |             |              |               | +                 | +                   | +                   | NA                  |
| Saygili et al. [69] |       |          |              |                             |             |             |              |               | +                 | +                   | +                   | NA                  |
| Shamshiri et al. [70]|      |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |
| Sharma et al. [71]  |       |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |
| Shlomai et al. [72] |       |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |
| Shmueli et al. [73] |       |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |
| Sladievicius et al. [74]|     |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |
| Verlue et al. [75]  |       |          |              |                             |             |             |              |               | −                 | −                   | −                   | −                   |
| Vijayaraghavan et al. [76]|   |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |
| Vijayaraghavan et al. [77]|   |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |
| Wilcox et al. [78]  |       |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |
| Yarhamid et al. [79] |       |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |
| Yosefy et al. [80]  |       |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |
| Yosefy et al. [81]  |       |          |              |                             |             |             |              |               | +                 | +                   | +                   | +                   |

1 (2) 8 (13) 0 (0) 3 (5) 1 (2) 21 (34) 4 (7) 15 (25) 14 (25) 9 (15) 15 (27) 5 (19)
Table 4 (continued)

| Author (References) | Resources and costs | Currency and price Conversion | Model description | Assumptions | Analytic methods | Result parameters | ICER | Uncertainty | Heterogeneity | Findings and limitations | Funding source | Conflict of interest | Score (% of applicable items) |
|---------------------|---------------------|-------------------------------|-------------------|-------------|-----------------|------------------|------|-------------|--------------|------------------------|----------------|-----------------------|-----------------------------|
| Al Abri et al. [22] | +                   | +                             | −                 | −           | −               | +                | +    | +           | −            | +                     | −              | +                     | 20 (83)                     |
| Al-Qudah et al. [23]| +                   | +                             | −                 | +           | +               | +                | +    | NA          | −            | +                     | +              | +                     | 18 (86)                     |
| Assanelli et al. [24]| +                   | +                             | −                 | −           | −               | +                | +    | +           | NA           | +                     | +              | +                     | 17 (77)                     |
| Balicer et al. [25] | +                   | −                             | −                 | +           | +               | +                | +    | −           | −            | −                     | −              | −                     | 12 (55)                     |
| Barfar et al. [26]  | +                   | +                             | −                 | +           | +               | +                | +    | −           | −            | +                     | +              | −                     | 21 (95)                     |
| Carvalho et al. [27]| +                   | −                             | +                 | +           | +               | +                | +    | NA          | −            | +                     | +              | −                     | 18 (82)                     |
| Chodick et al. [28] | +                   | −                             | +                 | −           | +               | −                | −    | −           | −            | +                     | −              | −                     | 19 (83)                     |
| Chodick et al. [29] | +                   | −                             | +                 | +           | −               | +                | +    | −           | −            | +                     | +              | −                     | 19 (79)                     |
| Chowers [30]        | +                   | +                             | +                 | +           | +               | +                | −    | −           | −            | −                     | −              | +                     | 20 (87)                     |
| Devine [31]         | +                   | −                             | −                 | +           | +               | +                | +    | −           | −            | −                     | −              | +                     | 20 (87)                     |
| El-Dahiyat [32]     | +                   | −                             | NA                | +           | −               | NA               | −    | NA          | −            | −                     | −              | +                     | 12 (67)                     |
| El-Ghitany [33]     | −                   | −                             | −                 | −           | −               | −                | −    | −           | −            | +                     | +              | +                     | 8 (35)                      |
| Eltabbakh et al. [34]| +                   | −                             | −                 | −           | −               | −                | −    | −           | −            | −                     | −              | +                     | 14 (58)                     |
| Gamaoun et al. [35] | −                   | +                             | +                 | +           | −               | +                | +    | −           | +            | +                     | −              | +                     | 17 (74)                     |
| Ginsberg et al. [36]| +                   | +                             | −                 | −           | −               | +                | +    | NA          | −            | −                     | −              | +                     | 17 (77)                     |
| Ginsberg et al. [37]| +                   | +                             | +                 | +           | +               | +                | +    | −           | +            | +                     | −              | +                     | 18 (78)                     |
| Ginsberg et al. [38]| +                   | +                             | +                 | +           | +               | +                | +    | −           | +            | +                     | +              | +                     | 21 (91)                     |
| Ginsberg et al. [39]| +                   | +                             | +                 | −           | −               | +                | +    | −           | +            | +                     | −              | +                     | 20 (83)                     |
| Ginsberg et al. [40]| +                   | +                             | −                 | +           | +               | +                | +    | −           | −            | +                     | +              | +                     | 18 (82)                     |
| Author (References) | Resources and costs | Currency and price conversion | Model description | Assumptions | Analytic methods | Result parameters | ICER | Uncertainty | Heterogeneity | Findings and limitations | Funding source | Conflict of interest | Score (% of applicable items) |
|---------------------|---------------------|-----------------------------|-------------------|-------------|-----------------|------------------|------|-------------|---------------|------------------------|----------------|---------------------|-----------------------------|
| Haghighat et al. [41] | + | + | + | + | + | + | + | + | + | + | + | 24 (100) |
| Hamdani et al. [42] | + | + | − | + | − | + | + | − | NA | + | + | + | 19 (86) |
| Howard et al. [43] | + | + | − | + | + | + | + | − | NA | + | + | + | 21 (88) |
| Hussain et al. [44] | + | + | + | + | + | + | + | − | NA | + | + | + | 23 (100) |
| Javadinasab et al. [45] | + | + | + | + | + | + | + | − | NA | + | + | + | 21 (88) |
| Javanbakht et al. [46] | + | + | + | + | + | + | − | − | − | + | + | + | 17 (77) |
| Kashi et al. [47] | + | + | NA | − | − | + | NA | − | NA | + | + | + | 10 (50) |
| Khneisser et al. [48] | + | − | NA | − | − | + | NA | − | NA | + | + | + | 11 (55) |
| Khneisser et al. [49] | + | − | NA | − | − | + | NA | − | NA | + | + | + | 23 (96) |
| Kim et al. [50] | + | + | + | + | + | + | + | − | + | + | + | 23 (100) |
| Kim et al. [51] | + | + | + | + | + | + | + | − | + | + | + | 13 (59) |
| Koren et al. [52] | + | + | − | − | − | + | − | − | NA | + | + | + | 18 (82) |
| Lahiri et al. [53] | + | − | + | − | − | + | + | − | − | + | + | + | 17 (77) |
| Leshno et al. [54] | + | + | + | + | + | − | + | + | NA | − | + | − | 18 (78) |
| Lim et al. [55] | + | − | + | + | + | + | − | − | + | − | − | + | + | + | + | + | 16 (70) |
| Lohse et al. [56] | + | − | + | + | − | + | + | − | NA | + | + | + | 22 (96) |
| Madae'en et al. [57] | + | − | + | + | + | + | + | − | NA | + | + | + | 20 (87) |
| Marseille et al. [58] | + | + | + | + | + | + | + | − | NA | + | + | + | 21 (91) |
| Mason et al. [59] | + | + | + | + | + | + | + | − | NA | + | + | + | 23 (100) |
| Messoudi et al. [60] | + | + | + | + | + | + | + | − | NA | + | + | + | 23 (100) |
| Author (References) | Resources and costs | Currency and price Conversion | Model description | Assumptions | Analytic methods | Result parameters | ICER | Uncertainty | Heterogeneity | Findings and limitations | Funding source | Conflict of interest | Score (% of applicable items) |
|---------------------|---------------------|------------------------------|-------------------|-------------|-----------------|------------------|-----|-------------|--------------|-------------------------|----------------|--------------------------|-----------------------------|
| Mostafa et al. [61]  | +                   | +                            | +                 | +           | +               | +                | +   | −           | +            | +                      | +             | +                        | 23 (96)                     |
| Mostafa et al. [62]  | +                   | +                            | +                 | +           | +               | +                | +   | −           | +            | +                      | +             | +                        | 23 (96)                     |
| Nahvijou et al. [63] | +                   | +                            | +                 | +           | +               | +                | +   | −           | +            | +                      | +             | +                        | 23 (96)                     |
| Okem et al. [64]     | +                   | +                            | +                 | +           | −               | +                | +   | −           | +            | +                      | +             | +                        | 16 (73)                     |
| Omooy et al. [65]    | +                   | −                            | −                 | +           | −               | –                | −   | +           | +            | +                      | +             | +                        | 15 (68)                     |
| Ranson et al. [66]   | +                   | −                            | −                 | +           | −               | +                | +   | −           | +            | +                      | +             | +                        | 18 (78)                     |
| Rashidian et al. [67] | +                  | −                            | −                 | +           | +               | +                | +   | +           | +            | +                      | +             | +                        | 22 (96)                     |
| Rezaei-Hemami et al. [68] | +    | −                            | −                 | −           | +               | −                | −   | +           | +            | +                      | +             | +                        | 14 (64)                     |
| Saygili et al. [69]  | +                   | −                            | −                 | +           | −               | +                | +   | −           | +            | +                      | +             | +                        | 15 (71)                     |
| Shamshiri et al. [70] | +                  | +                            | +                 | +           | +               | +                | +   | −           | +            | +                      | +             | +                        | 20 (87)                     |
| Sharma et al. [71]   | −                   | +                            | +                 | +           | −               | +                | +   | −           | +            | +                      | +             | +                        | 19 (83)                     |
| Shlomai et al. [72]  | +                   | −                            | +                 | +           | +               | +                | +   | −           | +            | +                      | +             | +                        | 19 (86)                     |
| Shmueli et al. [73]  | +                   | +                            | +                 | +           | +               | +                | +   | −           | +            | +                      | +             | +                        | 21 (91)                     |
| Sladkevicius et al. [74] | +    | +                            | +                 | +           | +               | +                | +   | −           | +            | +                      | +             | +                        | 20 (91)                     |
| Verquet et al. [75]  | −                   | −                            | +                 | +           | +               | +                | +   | −           | +            | +                      | +             | +                        | 17 (71)                     |
| Vijayarya-ghavan et al. [76] | +  | −                            | +                 | +           | +               | +                | +   | −           | +            | +                      | +             | +                        | 19 (86)                     |
| Vijayarya-ghavan et al. [77] | +  | −                            | −                 | +           | +               | +                | +   | −           | +            | +                      | +             | +                        | 19 (86)                     |
Table 4 (continued)

| Author (References) | Resources and costs | Currency and price Conversion | Model description | Assumptions | Analytic methods | Result parameters | ICER | Uncertainty | Heterogeneity | Findings and limitations | Funding source | Conflict of interest | Score (% of applicable items) |
|---------------------|---------------------|-------------------------------|-------------------|-------------|-----------------|-------------------|------|-------------|---------------|------------------------|----------------|------------------------|-----------------------------|
| Wilcox et al. [78]  | +                   | +                             | –                 | +           | +               | +                 | +   | +           | –             | +                     | +             | –                     | 19 (83)                      |
| Yarahmadi et al. [79]| –                   | –                             | NA                | –           | –               | –                 | –   | –           | NA            | –                     | +             | –                     | 12 (57)                      |
| Yosefy et al. [80]  | +                   | +                             | –                 | +           | –               | +                 | –   | +           | –             | –                     | +             | +                     | 18 (75)                      |
| Yosefy et al. [81]  | +                   | +                             | –                 | –           | +               | +                 | –   | –           | –             | –                     | –             | –                     | 16 (67)                      |
| No. of missed items (% applicable items) | 5 (8) | 21 (34) | 21 (37) | 9 (15) | 21 (34) | 3 (5) | 8 (14) | 20 (33) | 21 (64) | 2 (3) | 17 (28) | 17 (28) |

ICER: incremental cost-effectiveness ratio, NA: not applicable, (+): reported, (−): not reported
Palestine), and low-income countries (Sudan and Yemen). In these countries, HE and HTA studies are not mandatory in decision-making [6, 18, 19, 84, 85]. Meanwhile, these countries share some common features: the lack of HTA institutionalization, the absence of national HE guidelines, the lack of HE and HTA graduate and post-graduate academic programs, the limited technical capacity to conduct economic evaluation studies, and the fragility of UHC programs [6, 18, 19, 84, 85]. Another possible explanation for the low number of economic evaluation studies in high-income and low-income countries in MENA is that high-income countries (Gulf States) have sufficient financial resources to adopt expensive interventions, while public health interventions in low-income countries are mainly funded by donors and international agencies. Based on the results of this study, 19 studies (31%) and 11 studies (18%) were conducted in high- and low-income countries, respectively. On the other hand, 29 studies (48%) were conducted in middle-income countries. These middle-income countries have faced many challenges in adopting new public health interventions under finite resources; hence, HE and HTA evidence are greatly needed to support policy decision-making. As such, an increase in the number of economic evaluation studies from these countries shortly can be expected.

While this review found that most of the identified studies were of good quality, other factors influenced the transferability or generalizability of economic evaluation results across jurisdictions. These included epidemiological data, resource use, unit costs, utility value, health care delivery pattern, and effectiveness of public health interventions. As the MENA region comprises different countries in different geographies and income levels, these parameters might not be similar across all countries. For high-income countries in the region, this review identified 19 studies. Of which, 18 were from Israel, which might limit the generalizability or transferability to other high-income countries in the region (Gulf States) due to differences in the above factors. The researchers also identified 29 studies from middle-income countries, out of which 20 studies came from Egypt, Iran, and Pakistan. In this case, the studies identified in these middle-income countries can be generalized to other countries within the same income group in the region.

Furthermore, 11 studies from low-income countries were identified. Many of them were conducted as multi-country studies, indicating the possibility of transferring their results across low-income countries. Also, it is important to note that the transferability of such findings could not be applied solely to all countries in the region. Even within the same income group in the MENA region, similarities in terms of epidemiology data, disease burden, and patterns of health care delivery should be considered when transferring economic evaluation evidence. Generally, they can be transferred to close similar countries. For example, the findings of high-quality studies conducted in Pakistan can be transferred to Afghanistan and vice versa.

Similarly, high-quality studies conducted in Algeria, Morocco, and Tunisiaia can be generalized among these countries. The same can be applied to Iran, Iraq, Jordan, Lebanon, and Turkey. Although there was a limited number of economic evaluation studies in the region, the authors believe that transferability could be generally made across the middle- and low-income countries in the region, as they are less heterogeneous in terms of epidemiological parameters, patterns of healthcare delivery, unit cost, and utility values. Therefore, economic evaluation evidence is suitable to inform policy decision-making in similar settings but not in the wider range of the region. However, for decision-makers, careful consideration is required when transferring and adopting economic evaluation results from studies conducted outside their countries, and more economic evaluation studies are warranted to support evidence-based policy decision-making.

Second, there is also a gap in research quality: although the quality of the included studies was generally good [44 studies (72%) achieved scores of 75% or over], there is room to improve the overall quality of HE studies in this region. Utilizing locally-generated epidemiological data, unit cost of health service, effectiveness and utility data, model calibration and validation, dealing with skewed and missing data, and testing the robustness of results are all warranted. It is also required to explicitly describe the modeling approach and provide the model structure, mention the currency conversion methods and the exchange rates, report the perspective, and deal with heterogeneity. It is noteworthy that the number and quality of economic evaluation studies conducted in countries where HE academic programs, national HE guidelines, and HTA agencies exist (i.e., Egypt, Iran, Israel, Turkey, and Tunisia) tend to be much better than studies performed in countries where HE academic programs and guidelines are still inexistent.

As revealed by this study’s results, more than half of the studies conducted in the region (33 studies; 54%) were performed in 3 countries (i.e., Israel, Iran, and Egypt), where HTA and HE had formal roles in the decision-making process [18, 19]. Besides, the researchers observed that studies performed by health economists and public health professionals tended to be of better quality than studies performed by clinicians. Furthermore, the researchers noticed the relationship between the year of publication and the overall quality of the study. Studies published since 2015 tended to be of better quality than the previous studies. It may be due to the development of standards and guidelines aimed to ensure the quality of reporting in the HE field.

This study’s results showed that the economic evaluation studies were conducted for the following diseases: infectious diseases (21 studies; 34%), cancers (13 studies; 21%),
genetic disorders (nine studies; 15%), CVDs (seven studies; 12%), and other disease domains including maternal diseases, back pain, malnutrition, gestational diabetes mellitus, and mental diseases (11 studies; 18%). The observed research output did not adequately reflect the current and upcoming disease burden and risk factors trends in the MENA region. Currently, several MENA countries have some of the highest rates of NCD-risk factors, such as high blood pressure, obesity, physical inactivity, tobacco use, and high intake of salt, sugar and fats [15, 87]. Likewise, many diseases, such as CVDs, cancers, diabetes, and chronic lung and kidney diseases, are serious public health issues representing a significant disease burden in the MENA region. These risk factors and diseases place enormous pressures on the health system and resources; therefore, they require significant policy attention. For example, the MENA region experienced the highest global increase in the prevalence of diabetes mellitus in 2019 (12.2% of the adult population aged 20–79 years) and is expected to witness the second-highest increase (96%) in this prevalence between 2019 and 2045 compared to other parts of the world [88]. Similarly, a recently published review article indicated that the overall estimated pooled prevalence of hypertension in MENA was 26% and is estimated to double by 2025 [89]. Another recent study indicated that smoking prevalence was 62.7% and 27.5% among adult men and women in some MENA countries, respectively. These rates ranked among the highest worldwide [90].

On the other hand, MENA countries have witnessed many infectious disease outbreaks, such as polio outbreaks (Afghanistan, Pakistan, and Syria) and cholera outbreaks (Iraq and Yemen). Highly pathogenic and serious viral infections like hepatitis B and hepatitis C are also still an important risk of morbidity and mortality and pose a real threat to some MENA countries like Egypt. Similarly, malaria, hepatitis A virus, Chikungunya, dengue fever, cholera, diphtheria, Leishmaniasis, measles, and Rift Valley fever constitute major health, social, and economic challenges for several MENA countries [12, 91].

By the end of the study identification process, the researchers could find only one economic evaluation study on public health interventions to control and prevent COVID-19 [72]. Given the growing concern about the economic impact and value of such interventions (lockdowns, border closures, screening of suspected cases, tracing and isolating symptomatic individuals and their contacts, quarantine, personal protective equipment, and social distancing), the researchers may expect that the number of economic evaluation studies on COVID-19 interventions will increase globally, including the MENA region as these interventions have substantial economic and social consequences. In addition, a recent systematic review of these interventions suggested that screening and social distancing have been cost-effective in preventing and controlling COVID-19 over a long-time horizon. However, the evidence remains inconclusive and too heterogeneous to provide firm conclusions regarding the costs of the interventions [92]. In emergencies or epidemics such as COVID-19, it is not justified to delay policy decisions in priority areas due to the immaturity of scientific evidence (e.g., economic evaluation studies). Waiting for a better evidence base to judge the true value of potentially beneficial interventions increases the risk of infection spreading, which could have huge social and economic implications. However, decisions have to comply with the basic principles of what is considered good evidence-based decision-making practices as much as possible, while at the same time, additional data must be collected, generated, and evaluated; this strategy is called "coverage with evidence development". These decisions should be reviewed regularly as new evidence emerges [93].

Notably, there was a complete absence of economic evaluation studies on interventions targeting specific realms, such as physical inactivity, alcohol drinking, occupational health, and mental health. Previous global systematic reviews on economic evaluations of occupational health interventions also revealed no single study from the MENA region and a very limited number from other regions, indicating a great need for further research in these domains [94, 95]. Another study covering some MENA countries indicated that occupational health research is neglected, although occupational injuries have been reported to be high in these countries [91]. One potential reason for this negligence of occupational health research in MENA countries is the lack of experts or awareness about the importance of this discipline. Likewise, the lack of economic evaluation studies on mental health may result from the absence of governments' spending on mental health, insufficient capacity, and the absence of public health interventions in this field. Following the same pattern, the lack of economic evaluation studies on interventions targeting alcohol drinking may be caused by the fact that almost all MENA countries are dominated by Muslim populations, where drinking alcohol is religiously forbidden; therefore, these countries may not bear the same burden experienced in other regions. Meanwhile, the lack of economic evaluation studies on interventions promoting physical activity despite the region's high prevalence of diabetes, obesity, and NCDs cannot be justified.

Moreover, it is noteworthy that the researchers observed that most public health interventions were significantly cost-effective or even cost-saving. Even low-intensity public health interventions can have strong positive effects on the population's health in less developed countries and may positively impact the possibility of reducing poverty and boosting economic indicators and living standards. In this sense, a public health system that responds to the health need is a facilitator of human development since components of human capital, such as health and education, are positively
correlated with the quality of the public health system [96]. It is also evident that healthier countries tend to be wealthier than countries with lower health status, a relationship known as the “Preston curve” [97]. In addition, public health interventions may generate wider economic consequences than those related to the healthcare sector alone. Investing in public health interventions, therefore, extends to many other sectors, such as education, manufacturing, commerce, tourism, and transportation [98]. Paradoxically, despite proven benefits and long-term returns on investment, public health is frequently considered a politically easy target for budget cuts, as reported in some MENA countries and elsewhere [98].

Further, the findings of this review reflect a misperception of the role of public health in communities. In this region, as in other parts of the world, the political nature of policy-making processes is apparent where policy-makers tend to advocate for curative interventions and invest in building large hospitals and medical cities as they perceive it as the best way to foster health and well-being. However, the healthcare system has other tasks with prevention, health promotion, health education, and early disease detection even before one becomes ill and requires a hospital visit [99]. Thus, the focus must shift to upgrading the healthcare system to become more proactive, comprehensive, and integrated. As such, health issues can be addressed earlier, and quality healthcare services can be accessed once needed [100]. Guided by the WHO resolution on HTA in support of UHC [101] and motivated by the challenges of rising and escalating healthcare costs under the economic pressure these countries are suffering from, more serious local initiatives are required to establish a healthcare prioritization system (including HTA) transparently and legitimately, to ensure the sustainability of healthcare systems and to promote equitable, efficient, and high-quality healthcare services. In addition, worth mentioning that MENA countries began to implement effective interventions and policies to curb NCDs risk factors [13], yet these responses have been slow and appear not to be fully aligned with each country’s social, economic, and health situations [11]. Further, these policies have largely focused on clinical and curative activities rather than preventive, educative, and promotive services.

On the other side, disease burden is commonly seen as an important criterion for low- and middle-income countries (LMICs) in national decision-making to prioritize research directions [102–104]. While it is indicative of the potential scale of the population that would benefit from a healthcare intervention, understanding the value of interventions that target high disease burdens requires information about the cost of those interventions and the opportunity cost of funding them. It can be operationalized using a threshold reflecting health opportunity cost. Country-specific thresholds reflecting the healthcare system, local priorities, local preferences, and ability to pay are also needed in the MENA region (see Table 3). More details and discussions were also provided in previous reviews [6, 18, 19, 84–86].

This study is the first systematic review of economic evaluations of public health intervention in the MENA region, highlighting under-studied disease areas to fill these clear gaps. Although the strengths of this study lie in its rigorous and systematic search strategy, broad time horizon (database inception onwards), geographic coverage of all 26-MENA countries, and the quality assessment of included studies, this study has some limitations. First, it has been difficult to include all that constitutes a ‘public health intervention’ due to terminology diffusion. As such, the researchers had limited the search to the abovementioned terms. Second, the search was limited to studies published in English identified from the two main databases: PubMed and Scopus. Hence, this review did not include technical reports, HE, HTA, and other grey literature written in local languages. Concerning this, it can be argued that government institutions may perform more economic evaluation studies, but as in some other regions, they may not choose to publish their results due to the political environment in which the decision-making process remains largely secretive with limited transparency [105]. However, the full impact of such exclusions on this study’s results still requires further identification. Therefore, further studies covering more databases (Embase, Cochrane, and Cost-Effectiveness Analysis Registry, and others), unpublished studies, and studies published in local languages are warranted. Third, this review did not include HE studies that evaluated vaccines, diagnostic tools, pharmaceutical products, or other therapeutic interventions. These studies were evaluated separately to ensure harmony and consistency of compared studies, thus, gaining more insight into the specific characteristics of each group of interventions [18, 19]. Lastly, focusing on full HE studies, partial economic evaluations such as cost-of-illness studies were excluded from this review.

**Conclusions**

The number of economic evaluation studies on public health interventions conducted in MENA countries has increased in the past years; however, this number was still very limited, indicating that economic evaluation evidence is not widely used to guide public health decisions in the MENA region. Geographic gaps across countries in the region were also identified concerning the number of economic evaluation studies. In addition, this review found that the number of economic evaluation studies did not align with disease domains with the highest burden and the most prevalent risk factors in some countries. It suggested that MENA governments should prioritize the disease domains and innovative interventions when funding economic evaluation studies.
to reflect the health burden in the region better. Although the overall quality of the reviewed studies was good—more than two-thirds of them were of high to excellent quality—and were potentially useful for policy decision-making, the limited number of studies in high- and low-income countries and the transferability issues across jurisdictions since MENA region consisted of heterogeneous countries suggested that the existing economic evaluation evidence might not be sufficient to informed policy decision-making in the wider range of the region. The commitment to adopting economic evaluation evidence for public health policy decision-making and developing economic evaluation evidence on major disease burdens are also clearly warranted for efficient public health resource allocation in the MENA region. To facilitate this, national HE guidelines and institutionalizing HTA policy should be established in all countries.

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Author contributions
All authors attest that they met the International Committee of Medical Journal Editors (ICMJE) criteria for authorship. All authors contributed to the study’s conception and design. Material preparation, data collection, and analysis were performed by [Mouaddh Abdulmalik Nagi], [Mustafa Ali Ali Rezq], [Sermsiri Sangroongruangsri], [Montrat Thavomchareonseap], and [Pranitha Esha Nirmala Devi]. The first draft of the manuscript was written by [Mouaddh Abdulmalik Nagi]. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Code availability
Not applicable.

Declarations

Ethics approval and consent to participate
Ethical approval was not required for this study since it did not include human subjects.

Consent for publication
Not applicable.

Competing interests
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