Recent international communicable disease crises have highlighted the need for countries to assure their preparedness to respond effectively to public health emergencies. The objective of this study was to critically review existing tools to support a country’s assessment of its health emergency preparedness. We developed a framework to analyze the expected effectiveness and utility of these tools. Through mixed search strategies, we identified 12 tools with relevance to public health emergencies. There was considerable consensus concerning the critical preparedness system elements to be assessed, although their relative emphasis and means of assessment and measurement varied considerably. Several tools identified appeared to have reporting requirements as their primary aim, rather than primary utility for system self-assessment of the countries and states using the tool. Few tools attempted to give an account of their underlying evidence base. Only some tools were available in a user-friendly electronic modality or included quantitative measures to support the monitoring of system preparedness over time. We conclude there is still a need for improvement in tools available for assessment of country preparedness for public health emergencies, and for applied research to increase identification of system measures that are valid indicators of system response capability.

Key Words: assessment, emergency preparedness, Europe, health system, planning, public health, tool
Preparedness assessment tools were included, and search filters were chosen to be non-restrictive in order to increase search sensitivity. These are given in Table 1. Inclusion criteria were:

1. Period: 2000–2017;
2. Languages: reports published in English, Spanish, French, German, or Italian;
3. Category: humanities;
4. Scope: subnational, national, or international;
5. Type of hazard: generic (ie, all-hazards approach), or pandemic influenza; and
6. Presence of a checklist, indicators, or measures to assess national public health emergency preparedness status.

Civil protection emergency assessment tools were excluded if they did not include public health or health care aspects of the emergency response. The gray literature search included international and national public health and civil defense websites.

A framework to review and compare the identified tools was developed by the investigators, drawing substantively on criteria developed by Nelson et al.10 and Asch et al.9 Complementary indicators were extracted from these publications and combined in a single analytical framework, together with 2 further indicators developed by the authors (“completeness,” “main advantages”) (Table 2).

| TABLE 1 MEDLINE and Gray Literature Search Strategies |
|-------------|-----------------------------------------------------|
| **Source**  | **Search Strategy**                                  |
| MEDLINE   | (“public health” [All Fields] OR “health system” [All Fields]) AND (“emergencies” [MeSH Terms] OR “emergencies” [All Fields] OR “emergency” [All Fields] OR “disasters” [MeSH Terms] OR “disasters” [All Fields] OR “disaster” [All Fields] OR “pandemics” [MeSH Terms] OR “pandemics” [All Fields] OR “pandemic” [All Fields] OR “preparedness” [All Fields] OR “response” [All Fields] OR “planning” [All Fields] OR “assessment” [All Fields] OR “toolkit” [All Fields]) AND (“measurement” [All Fields]) OR (“toolkit” [All Fields]) OR (“standard” [All Fields]) AND (“2000/01/01” [PDAT]: “2017/08/29” [PDAT]) AND “humans” [MeSH Terms]) (“public health” OR “health system”) AND (emergency OR disaster OR pandemic) AND (planning OR preparedness OR response) AND (evaluation OR assessment OR measurement OR tool OR toolkit OR checklist OR standard) Websites: World Health Organization; European Centre for Disease Prevention and Control; European Commission; European Parliament; United Nations; Organization for Security and Cooperation in Europe; United States Centers for Disease Control and Prevention; Ministries of Health and of Security and Civil Defence (European Union and European Economic Area countries; United States; New Zealand; Australia; Canada) |

The 12 tools identified are summarized in Table 3. All were published between 2009 and 2016. Seven of the 12 tools were developed by international authorities or organizations.13-18,22 The other 5 were country-specific: from England,19 New Zealand,20 and the United States.11,12,21 Some of the tools developed by international organizations had a primary focus on voluntary country level implementation.13,17,18,22 Others had an apparent primary rationale of required or recommended reporting under international or European regulations.14,16

Since both tool acronyms are EPREP, we have specified the Harvard tool as H-EPREP and EpiSouth tool as E-EPREP.
Appraisal of the tools according to the evaluation framework is summarized in Table 4. All tools identified had governmental or institutional authorities as the principal target audience and specified an accountable entity, but with varying degrees of detail. Although all tools had public health emergencies as a primary focus, they varied in their relative emphasis on various aspects of emergency preparedness, including health system resilience and the wider civil emergency protection function. All except 1 took an all-hazards approach, although they mainly focused on communicable (infectious) disease emergencies with some additional sections for other types of public health hazard such as chemical or radiological events.

The key assessment areas included in each of the tools are outlined in Table 5. Some areas were common to nearly all tools,
### TABLE 4

**Evaluation Framework and Comparison of Identified Tools**

| Name of the Tool | General Description | Target Audience | Scope | Type of Hazard | Completeness (criteria based on Table 4) | Clarity of Measurement Parameters | Validity and Specificity of Scope and Measurement Parameters | Evidence Based | Feasibility | Utility | Accountable Entity Specified |
|------------------|---------------------|-----------------|-------|---------------|------------------------------------------|-----------------------------------|----------------------------------|----------------|-------------|--------|----------------------------|
| EC Technical Guidance on Generic Preparedness Planning for Public Health Emergencies¹³ | Checklists (tasks for every outcome expected) outlining the essential minimum requirements for public health emergency preparedness | European Union (EU) Member States government authorities, European Commission (EC) and Agencies | International and national | All hazards | Incomplete: recovery, community preparedness, and funding areas not covered | Clear description of indicators, Binary (yes/no) answer system | National focus included, High specificity to EU, Very high level of detail, no validation described, No quantification | Expert-consensus | Limited by its comprehensiveness (covers a large number of dimensions and themes) and by its format (paper based, plain text) | Includes qualitative self-rating measures, List of tasks | Yes |
| EC Template for Reporting on Decision No 1082/2013/EU¹⁴ | Checklist (questions and indicators) assessing four areas for managing serious cross-border threats | EU Member States government authorities | International and national | All hazards | Incomplete: focus only on IHR core capacities monitoring, interoperability, business continuity management, and evaluation of plans | Clear description of questions and indicators, Open or (yes, no, not known) answer system | National focus, High specificity to EU, High level of detail in some indicators but many open questions, no validation described, No quantification | Expert-consensus | Limited by its format (paper based, plain text, several tables with different formats, different type of answers mixed) | Include qualitative self-rating measures, List for inter-sectoral collaboration | Yes |
| WHO Questionnaire for Monitoring IHR Core Capacities in States Parties¹⁵ | Checklist with 244 global indicators for monitoring the development and maintenance of international health regulations (IHR) 13 core capacities | World Health Organization (WHO) Member States government authorities responsible for implementing IHR | International and national | All hazards | Incomplete: recovery, business continuity management, community preparedness, and other areas not covered | Clear description of indicators, Open or (yes, no, not known) answer system | National focus, Low specificity to EU, High level of detail and specificity of questions, external validation, Simple quantification | Expert-consensus | Although paper based, it is clear and simple | Includes qualitative self-rating measures, Includes qualitative self-rating and external evaluation measures | Yes |
| WHO Joint External Evaluation Tool¹⁶ | Checklist with 48 global indicators for regular external evaluations of a country’s IHR capacity (~every 5 years). Voluntary country participation | WHO Member States government authorities responsible for implementing IHR | International and national | All hazards | Incomplete: recovery, business continuity management, community preparedness, and other areas not covered | Clear description of indicators | National focus | Expert-consensus. Also incorporates content and lessons learned from tested external assessment tools and processes of other multilateral and multi-sectoral initiatives | Simple quantification | Includes qualitative self-rating and external evaluation measures | Yes |
| Name of the Tool | Main Advantages | General Description | Target Audience | Scope | Type of Hazard | Completeness (criteria based on Table 4) | Clarity of Measurement Parameters | Validity and Specificity of Scope and Measurement Parameters |
|------------------|-----------------|---------------------|-----------------|-------|----------------|----------------------------------------|---------------------------------|---------------------------------|
| EC Technical Guidance on Generic Preparedness Planning for Public Health Emergencies | Comprehensive scope: almost all dimensions covered Focus on EU countries Useful list of tasks | Checklist with 51 essential attributes, corresponding to 16 key components of each of the 6 WHO health system framework functions blocks | EU Member States Coordination Group (public health and other institutions) responsible for health sector crisis management | National | All hazards | Incomplete: recovery, business continuity management, community preparedness, and evaluation not covered | Clear description of indicators Traffic lights system methodology (yes, partial, no) | National focus Low specificity to EU Good level of detail and specificity of indicators, no validation described No quantification |
| EC Template for Reporting on Decision No 1082/2013/EU | Includes Interoperability, business continuity management, and evaluation of plans Focus in EU countries Mandatory requirement of the EC | Checklist with 20 goals and corresponding key indicators for pandemic influenza preparedness | EU Member States person(s) responsible for the national pandemic planning and preparedness | National | Influenza | Incomplete: not all hazards and risk based approach, several dimensions not covered | Clear description of indicators | National focus High specificity to EU Focus on one disease Good level of detail and specificity of indicators, no validation described No quantification |
| WHO Questionnaire for Monitoring IHR Core Capacities in States Parties | International standards (wide consensus) Comprehensive scope Mandate by the WHO | Checklist with 37 generic and 13 specific (hazardous materials and chemical, biological, radiological, and nuclear events) response core standards | National Health System (NHS) organizations and providers of NHS funded care system | National and subnational | All hazards | Almost complete: recovery and health system operational response not fully covered | Clear description of indicators Traffic lights system methodology (yes, partial, no) | National focus High specificity to subnational sector Good level of detail of indicators and assurance mechanisms, high specificity but no validation described No quantification |
| WHO Joint External Evaluation Tool | International standards (wide consensus) Comprehensive scope Voluntary requirement of the WHO: first time will be a baseline measurement of the country’s capacity and capabilities. Subsequent evaluations will identify progress made and ensure any improvements in capacity are sustained | Index based on key performance indicators and measures organized in 6 sections: 4 based on goals of the National Civil Defence and Emergency Management (CDEM) strategy and 2 “enabler” sections | New Zealand public health agencies and CDEM groups | National and subnational | All hazards | Almost complete: health system operational response not fully covered | Very clear description of indicators Scoring system methodology | High specificity to subnational sector Very high level of detail of indicators but no validation described Quantitative and comparative assessment (index) |
| Name of the Tool | General Description | Target Audience | Scope |
|------------------|---------------------|-----------------|-------|
| WHO Toolkit for Assessing Health System Capacity for Crisis Management | Checklist with 15 public health emergency preparedness capabilities organized in 6 categories. Each capability includes a list of functions, performance measures, tasks, and resource considerations | United States (US) state and local public health departments | National and subnational |
| Joint European Pandemic Preparedness Self-Assessment Indicators | Exercise evaluation tool: combination of checklists and rating scales to produce quantifiable representations of 160 tasks and 500 related actions to assess performance | US state and local public health organizations | National and subnational |
| NHS England Core Standards for EPRR | Includes qualitative self-rating measures | User-friendly (Excel format) | High specificity to subnational sector |
| CDC Public Health Preparedness Capabilities | Index based on 128 indicators, organized in 5 domains and 14 subdomains measuring key areas of public health emergency preparedness. National results are calculated by averaging the 50 states | Health sector of Mediterranean Basin EU and non-EU countries | National |
| Emergency Preparedness Exercise Evaluation Tool (H-EPREP) | Not described | US policy-makers, practitioners, researchers, and communicators | National and subnational |
| United States NHP | Not described | | |
| EpiSouth Network E-EPREP | Not described | | |
| Name of the Tool | CDC Public Health Preparedness Capabilities<sup>21</sup> | Emergency Preparedness Exercise Evaluation Tool (H-EPREP)<sup>12</sup> | United States NHSPI<sup>11</sup> | EpiSouth Network E-EPREP<sup>22</sup> |
|------------------|--------------------------------------------------|--------------------------------------------------|----------------------------------|----------------------------------|
| Type of Hazard   | All hazards                                      | All hazards                                      | All hazards                      | All hazards                      |
| Completeness     | Incomplete: governance, legal framework, and other areas not covered | Incomplete: governance, legal framework, and other areas not covered | Incomplete: governance, legal framework, funding, and other areas not covered | Almost complete                  |
| Clarity of Measurement Parameters | Clear description of the few indicators included | Very clear description of performance measures | Very clear description of indicators | Very clear description of expected outcomes |
| Completeness (criteria based on Table 4) | Incomplete: governance, legal framework, and other areas not covered | Very clear description of performance measures | Complex scoring system methodology | |
| Validity and Specificity of Scope and Measurement Parameters | Focus on US needs, high specificity to subnational sector, very high level of detail of the few indicators but no validation described, limited qualitative assessment (no quantification) | Focus on US needs, high specificity to subnational sector, very high level of detail of the few indicators but no validation described, limited qualitative assessment (no quantification) | Focus on US needs and data availability, high specificity to subnational sector, very high level of detail of the few indicators but no validation described, limited qualitative assessment (no quantification) | National focus, high level of detail of tasks, no quantification |
| Evidence Based   | Systematic approach: based on evidence-informed documents, applicable preparedness literature, and subject matter expertise gathered from across the federal government and the state and local practice community | Systematic approach: based on lessons learned from discussions with expert practitioners, from review of literature, and available tools | Validation method described: tested for reliability, usability, and validity by independent evaluators during multiple exercises | Validation problem: indicators chosen favors readily collectable measures |
| Feasibility      | Although paper based, it is a clear and relatively short list of tasks | It is an online interactive tool with Excel outputs, very easy to use | It is an online tool with data query functionalities, very easy to use | Not described |
| Utility          | List of tasks, includes some qualitative self-rating measures | Includes qualitative and quantitative measures for assessing US Public Health Preparedness Capabilities, standardized but can be customized | It is not a self-assessment, includes quantitative measures, allows comparability between states (high transparency) | Available as both a descriptive tool (limited feasibility because it is paper based and very comprehensive) and as online interactive tool (easier to use) |
| Accountable Entity Main Advantages | Not applicable | Yes, very user-friendly, online database of exercise evaluation measures that allows to generate customized exercise evaluation forms, store, and send them to multiple evaluators via e-mail, and generate basic reports, validation assessment described | Yes, comprehensive scope, user-friendly, quantitative and comparative assessment but it is made centrally by a large committee representing more than 25 organizations (it is not a self-assessment) | Yes, includes interoperability/inter-sectoral collaboration, useful description of tasks, possibilities for ongoing updating and revisions |
with varying degrees of detail and methodological approaches, for example, interoperability and inter-sectoral collaboration, crisis management and operations, planning, communication and information systems, and human resources and capability development. Other assessment areas were addressed less frequently, for example, recovery, community preparedness, cross-border issues, or ethical aspects.

Most tools identified provided little or no information on the criteria or decision processes used to identify the measures included in them, or the evidential approach taken for their development. Exceptions included the JEE,16,17 CDC,21,18 H-EPREP,12 and NHSPI11 tools. In most cases, the development of preparedness standards appeared to be based primarily on consultations with groups of experts. Only a minority of tools attempted to describe a conceptual and strategic framework underlying their design.11,12,21 The Civil Defence and Emergency Management Tool20 from New Zealand had the most comprehensive, logical, and updated framework, consistent with current concepts of health emergency preparedness.23,28

Most of the selected tools had clear measurement parameters, with different methodological formats and complexity. These varied from a detailed list of tasks13-15,21,22 to simple qualitative scales,12,16-19 through to more complex scoring systems.11,20

Four of the tools included a quantitative element: JEE,16 CDC,20 H-EPREP,12 and NHSPI.11 The CDEM tool had a scoring system with weighted indicators that can be customized according to national or regional priorities.20

Seven of the tools were paper-based only, with no electronic informatics to facilitate use.13-18,21 Two were presented for use as an Excel file (NHS19 and CDEM20), and 3 had online modalities (H-EPREP,12 NHSPI,11 and E-EPREP22). Two allowed a degree of customization by the user: CDEM20 and H-EPREP.12 H-EPREP12 was an exception, providing for the generation of

### TABLE 5

| Key Areas                                                    | EC 13 | EC 14 | WHO 15 | WHO 16 | WHO 17 | WHO 18 | NHS 19 | CDC 20 | H-EPREP12 | NHSPI | E-EPREP 22 |
|--------------------------------------------------------------|-------|-------|--------|--------|--------|--------|--------|--------|-----------|-------|-----------|
| Health crisis management and principles of operation        | X     | X     | X      | X      | X      | X      | X      | X      | X         | X     | X         |
| Health sector incident management and hospital preparedness | X     | X     | X      | X      | -      | -      | -      | -      | X         | X     | X         |
| Recovery planning and management                            | -     | -     | -      | -      | -      | -      | -      | -      | X         | X     | X         |
| Evaluation of response                                      | X     | X     | X      | X      | X      | X      | X      | X      | X         | X     | X         |
| Community resilience, preparedness, and recovery            | X     | X     | X      | X      | X      | X      | X      | X      | X         | X     | X         |
| Governance                                                  | X     | X     | X      | X      | X      | X      | X      | X      | X         | X     | X         |
| Management and testing of plans                             | X     | X     | X      | X      | X      | X      | X      | X      | X         | X     | X         |
| Legal framework                                             | X     | X     | X      | X      | X      | X      | X      | X      | X         | X     | X         |
| Ethical considerations                                      | -     | -     | -      | -      | -      | -      | -      | -      | -         | -     | -         |
| Funding                                                     | X     | X     | X      | X      | X      | X      | X      | X      | X         | X     | X         |
| Business continuity management                              | X     | X     | -      | -      | -      | -      | -      | -      | -         | -     | -         |
| Communication systems and management                        | X     | X     | X      | X      | X      | X      | X      | X      | X         | X     | X         |
| Information systems and management                          | X     | X     | X      | X      | X      | X      | X      | X      | X         | X     | X         |
| Scientific/evidence-based advise                            | X     | X     | X      | X      | X      | X      | X      | X      | X         | X     | X         |
| Human resources and capability development                  | X     | X     | X      | X      | X      | X      | X      | X      | X         | X     | X         |
| Interoperability and Inter-sectoral collaboration           | X     | X     | X      | X      | X      | X      | X      | X      | X         | X     | X         |
| European Union level considerations                         | X     | X     | -      | -      | -      | -      | -      | -      | -         | -     | -         |
customized exercise evaluation forms, storage, transmission to multiple evaluators by e-mail, and generation of basic reports.

DISCUSSION
The use of systematic methods and tools for system assessment should have substantive benefits for the preparedness of countries for public health emergencies. The tool infrastructure should in itself have symbolic value to help communicate a coherent view of the emergency preparedness system to all participants. This should cover all of the elements critical to ensuring an effective response, including effective collaboration across sectors and between countries in responding to cross-border events. The systematic assessment of these elements should enable gaps and weaknesses to be proactively identified and addressed. To achieve this, tools should include assessment items, which are valid indicators of actual performance in an emergency. They should be available in user-friendly electronic modalities and include quantitative elements to support the monitoring of system preparedness over time and voluntary benchmarking with others, to promote learning and system improvement.

We have identified 12 presently available tools to support assessment of country preparedness for public health emergencies. Most tools were found through national and international websites, and it is possible that more may have been identified through gray literature in languages other than those included in this search, at subnational level, and sources such as post-graduate theses.

Few of the identified tools meet all of the above requirements. We acknowledge a potential limitation of our appraisal in that the tools were evaluated as a desktop exercise based on *a priori* criteria; however, the evidence base from user experience of the presently available tools is almost non-existent.

Our review suggests some possible contributing perspectives on this present situation. Available tools appear to have been developed with somewhat different primary aims and methodological approaches. Most tools developed by international agencies and 1 in the United States appeared to focus primarily on standard reporting requirements to which countries and states are subject. Exceptions included the self-evaluation checklists developed by the European Commission and the WHO Regional Office for Europe, which appear to be designed explicitly for country use. Tools developed by national authorities provide a primary focus on the evaluation needs of the country but may not extrapolate well for use by others, given country-specific characteristics of health and public health emergency response systems. Further, country-level tools may have less utility for subnational (regional, local) jurisdictions, and vice versa.

Country preparedness evaluations need to assess not only plans and capacities, but also system capabilities for effective response to actual emergencies. Several tools relied heavily on input data relating to system capacities and resources; while information concerning these is often readily available, it may be only indirectly predictive of the capability to respond to an emergency. Nelson et al. observed in 2007 that the few tools then available to assess preparedness status tended to focus on capacities, and little evidence existed that linked specific structures with the ability to execute effective response processes, noting that “structural measures may not be valid indicators of preparedness.” In reporting on a review of national influenza pandemic preparedness plans in the EU in 2012, Nicoll noted that some national authorities had ceased further preparedness development after producing written plans and had neither developed operational aspects nor tried to assess whether they would work in practice. The present study suggests only modest advance in this respect; among the identified tools, only the CDEM, H-EPREP, and JEE tools included significant consideration of system capabilities, as well as capacities.

The evidence base linking preparedness capacities and capabilities to health outcomes remain weak. Asch et al. noted in 2005 that most instruments for assessing public health emergency preparedness relied excessively on subjective or structural measures and lacked a scientific evidence base. Previous literature reviews have found that the majority of journal articles were commentaries and anecdotal case studies, based on qualitative analyses, a situation unchanged in our present literature search in support of this critical tools analysis (to be reported separately). One systematic review concluded that most studies lacked a rigorous design, raising questions about the validity of the results. It appears that more and better quality research into public health emergency management is needed for the development of useful assessment tools, and the validity of presently assessed system elements as predictive of actual response capability remains largely unverified. This is also the conclusion of the developers of other tools, which attempted to provide some evidence-based approach, who ended up relying mainly on lessons learned documents (see Table 4). A focus of future research should include the comparison of preparedness system *a priori* assessment scores and the actual system performance outcomes in real-life incidents and emergencies.

As the tools reviewed did not have a documented strong evidence base, there was only partial consensus on the system elements critical for public health emergency preparedness, and how they may be assessed or measured. Although some system areas were common to most tools, there was significant diversity in the system elements included and their emphasis across the tools reviewed, and in the indicators or standards used to measure their effective presence. “The problem lies not in the absence of standards per se, but in the multiplicity of overlapping (and sometimes conflicting) standards.”

One issue underlying indicator development appears as differing preferences for standardizing all system measures, or leaving
countries’ flexibility to modify, add, or delete them. Some authors have recommended standardization of all assessment measures in order to facilitate comparisons, either to a “gold standard” or between countries. However, some emergency response leaders consider that this is less useful than a flexible country-specific tool, given different country administrative structures and health care systems. Respondents to the EU pandemic influenza preparedness review in 2009 considered that “instead of [standardized] indicators, it would be more useful to develop a tool describing the main areas for consideration in pandemic influenza preparedness planning. Each country may then add its own criteria, indicators or outcomes for determining whether something is in place.”23 This choice, in turn, appears to also reflect divergent views on the perceived value of sharing country information and benchmarking with others. In the same review, “a number of member states made it clear to the ECDC that the country specific results should only be known to the country […] and that specifically there would be no ‘league tables’.”23

Few tools were available in user-friendly, electronic modalities that could facilitate data gathering, analysis, and dissemination and discussion of results by participants and stakeholders. H-EPREP was an exception, as it also allowed the generation of customized exercise evaluation forms, storage, transmission to multiple evaluators by e-mail, and generation of basic reports. Developers should therefore be encouraged to produce assessment tools in more user-friendly modalities. Inclusion of quantitative scoring systems usefully support the monitoring of progress in the development of a country’s public health emergency preparedness over time. Such quantitative scoring systems can also facilitate voluntary benchmarking with other countries. However, few tools included this feature. Only 2 tools had been published in a manner accessible to a conventional literature search; most were available only through the websites of the organizations that developed them.

CONCLUSIONS

Methods and processes for assessment of country systems are an integral part of a holistic approach to assuring country emergency preparedness, including simulation exercises, after action reports and peer reviews.31 We conclude, however, that few of the existing tools satisfy all or most of the requirements for utility and effectiveness discussed previously. There is a continuing need for further improvement in tools available for countries’ assessment of their preparedness for public health emergencies. Existing tools could be revised with critical review of the validity of their assessment elements and indicators, and availability in more user-friendly electronic format with analytical and reporting modalities. New tools could be developed de novo at country and supranational level based on both a country’s needs and best available evidence relating to the validity of its assessment elements and indicators.

The paucity of applied emergency response systems research remains a significant impediment to achieving these improvements. In particular, the elements of the preparedness system that are valid indicators of actual response capability remain poorly understood. Reporting and critical review of user experience of all of the different means of evaluating country preparedness should contribute to this goal.31

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Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Authors’ Contributions

MH researched the literature and reviewed the tools; RCP researched the literature and reviewed the results; PR and GF were study investigator and commissioner, respectively; MH and GF wrote the manuscript; and ST, PR, UR, RCP, and MC critically reviewed the manuscript.

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