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Report of the United Nations Scientific Committee on the Effects of Atomic Radiation

Sixty-sixth session (10–14 June 2019)

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Note

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Chapter I

Introduction

1. Since the establishment of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) by the General Assembly in its resolution 913 (X) of 3 December 1955, the mandate of the Committee has been to undertake broad assessments of the sources of ionizing radiation and its effects on human health and the environment.[1] In pursuit of its mandate, the Scientific Committee thoroughly reviews and evaluates global and regional exposures to radiation. The Committee also evaluates evidence of radiation-induced health effects in exposed groups and advances in the understanding of the biological mechanisms by which radiation-induced effects on human health or on non-human biota can occur. Those assessments provide the scientific foundation used, inter alia, by the relevant agencies of the United Nations system in formulating international standards for the protection of the general public, workers and patients against ionizing radiation;[2] those standards, in turn, are linked to important legal and regulatory instruments.

2. Exposure to ionizing radiation arises from naturally occurring sources (such as radiation from outer space and radon gas emanating from rocks in the Earth) and from sources with an artificial origin (such as medical diagnostic and therapeutic procedures; radioactive material resulting from nuclear weapons testing; energy generation, including by means of nuclear power; unplanned events such as the nuclear power plant accidents at Chernobyl in April 1986 and that following the great east-Japan earthquake and tsunami of March 2011; and workplaces where there may be increased exposure to artificial or naturally occurring sources of radiation).

[1] The United Nations Scientific Committee on the Effects of Atomic Radiation was established by the General Assembly at its tenth session, in 1955. The terms of reference of the Committee are set out in resolution 913 (X). The Scientific Committee was originally composed of the following Member States: Argentina, Australia, Belgium, Brazil, Canada, Czechoslovakia (later succeeded by Slovakia), Egypt, France, India, Japan, Mexico, Sweden, Union of Soviet Socialist Republics (later succeeded by the Russian Federation), United Kingdom of Great Britain and Northern Ireland and United States of America. The membership of the Scientific Committee was subsequently enlarged by the Assembly in its resolution 3154 C (XXVIII) of 14 December 1973 to include the Federal Republic of Germany (later succeeded by Germany), Indonesia, Peru, Poland and the Sudan. By its resolution 41/62 B of 3 December 1986, the Assembly increased the membership of the Committee to 21 members and invited China to become a member. In its resolution 66/70, the Assembly further enlarged the membership of the Committee to 27 and invited Belarus, Finland, Pakistan, the Republic of Korea, Spain and Ukraine to become members.

[2] For example, the international basic safety standards for radiation protection and safety of radiation sources, currently co-sponsored by the European Commission, the Food and Agriculture Organization of the United Nations (FAO), the International Atomic Energy Agency (IAEA), the International Labour Organization (ILO), the Nuclear Energy Agency of the Organization for Economic Cooperation and Development (OECD), the Pan American Health Organization, the United Nations Environment Programme (UNEP) and the World Health Organization (WHO).

Chapter II

Deliberations of the United Nations Scientific Committee on the Effects of Atomic Radiation at its sixty-sixth session

3. The Scientific Committee held its sixty-sixth session in Vienna from 10 to 14 June 2019.[3] The Committee elected as officers of the Committee for its sixty-sixth and sixty-seventh sessions: Gillian Hirth (Australia) as Chair; Jing Chen (Canada), Anna Friedl (Germany) and Jin Kyung Lee (Republic of Korea) as Vice-Chairs; and Ingemar Lund (Sweden) as Rapporteur.

4. The Scientific Committee took note of and discussed General Assembly resolution 73/261 on the effects of atomic radiation, in which the Assembly, inter alia: (a) noted with concern the developments which resulted in the request by the Scientific Committee at its sixty-fifth session to the Office of Internal Oversight Services to conduct (i) an investigation or inspection into the process to recruit the Scientific Secretary to ensure that the successful candidate is selected on the basis of scientific qualifications and credibility and that the process is aligned with Article 101, paragraph 3, or the Charter of the United Nations; and (ii) an internal audit or evaluation to clarify whether the United Nations Environment Programme (UNEP) is the most appropriate body to serve the Committee in the future; (b) requested UNEP to continue, within existing resources, to service the Committee and to disseminate its findings to Member States, the scientific community and the public and to ensure that the administrative measures in place are appropriate, including clear roles to efficiently service the Committee in a predictable and sustainable manner and effectively facilitate the use of the invaluable expertise offered to the Committee by its members in order that the Committee may discharge the responsibilities and mandate entrusted to it by the General Assembly; (c) regretted that the UNEP secretariat had not appointed a new Secretary of the Committee in a timely manner, thereby jeopardizing continuity in the Committee secretariat, and insisted that all steps be taken to ensure such continuity and that any ongoing selection process is expedited and managed in a transparent manner; (d) requested the Secretary-General to strengthen support for the Committee within existing resources, particularly with regard to the deputization of the Secretary of the Committee, the avoidance of disruptions in staffing and the increase to operational costs in the case of a further increase in membership, and to report to the General Assembly at its seventy-fourth session on those issues; and (e) adopted a procedure for possible further increases in the membership of the Committee.

5. In regard to point (c), the Scientific Committee welcomed the new Secretary, Borislava Batandjieva-Metcalf, who was appointed by UNEP at the end of 2018 and commenced work in the role of Secretary on 16 April 2019. In regard to point (e), the Committee also welcomed the new and transparent procedure for the possible future increase in membership of the Committee.

6. In regard to points (a), (b), (c) and (d), the representative of Belgium made a statement about the negative impact of the delay in the appointment of a new Secretary, noting that there were a number of lessons to be learned to ensure that history did not repeat itself. The statement was supported by the representatives of Argentina, Germany and Poland. The representative of UNEP responded to the statement. Lessons learned, issues raised and the response by UNEP are reported in chapter II, section E, “Administrative issues”.

[3] The sixty-sixth session of the Scientific Committee was attended by observers from Algeria, Iran (Islamic Republic of), Norway and the United Arab Emirates, in accordance with General Assembly, resolution 73/261, para. 20, and observers for the UNEP, the International Agency for Research on Cancer, IAEA, ILO, WHO, the European Union, the International Commission on Radiation Units and Measurements and FAO.

A. Completed evaluations

7. The Scientific Committee discussed two substantive evaluations in detail, adopted the scientific reports on the basis of the findings of those evaluations (see chapter III) and requested that the scientific annexes be published in the usual manner, subject to the agreed modifications.

8. The Scientific Committee decided at its sixty-third session that it was essential to have an expert estimation of the knowledge of risk based on published studies for five combinations of health effects and conditions of exposures to ionizing radiation: (a) leukaemia incidence after computed tomography (CT) scans in childhood; (b) leukaemia mortality after occupational exposure; (c) mortality from all solid cancers after occupational exposure; (d) thyroid cancer incidence after ^{131}I intake during childhood; and (e) cardiovascular disease mortality after exposure to external radiation. The objective was to perform quantitative risk evaluations of health effects in specific exposure situations with low-to-moderate doses for cancer and in situations with higher doses for circulatory diseases, taking into account various sources of uncertainty of risk estimation. At its sixty-sixth session, the Committee discussed and approved for publication the scientific annex on the evaluation of selected health effects and inference of risk due to radiation exposure.

9. At its sixty-third session, during deliberations on its future programme of work, the Scientific Committee recalled that it had previously assessed the effects of exposure to radon in homes and workplaces in annex E to the UNSCEAR 2006 report,[4] in which it reiterated its assessment that inhalation of radon and its decay products was carcinogenic for the lungs. The Committee also noted that since that last comprehensive evaluation, there had been many new scientific publications concerning the issue and agreed to thoroughly re-assess the literature with a view to clarifying and assessing recent developments in risk estimates for lung cancer from exposure to radon.

10. The Scientific Committee agreed to conduct an evaluation on lung cancer from exposure to radon with the objective of addressing the following questions: (a) What is the current status of evidence and confidence regarding increased frequency of lung cancer for smokers and non-smokers, and for subgroups differentiated by age and sex, due to exposure to radon and thoron? (b) What are the associated uncertainties by assigning a dose to a given incorporation of radioactivity of radon (^{222}Rn) and thoron (^{220}Rn) in order to estimate health effects and risks or by estimating possible health effects attributable to radon and thoron exposure directly from epidemiological evidence? and (c) What dose conversion factors are to be used by the Committee in its future assessments of global exposure to radon (^{222}Rn) and thoron (^{220}Rn) in workplaces and homes? At its sixth-sixth session, the Committee discussed and approved for publication the scientific annex on lung cancer from exposure to radon.

B. Present programme of work

1. Biological mechanisms relevant for the inference of cancer risks from low-dose radiation

11. At its sixty-third session, the Scientific Committee decided to compile an up-to-date overview of current knowledge about the biological mechanisms by which radiation influences the development of disease, in particular at low incremental doses and dose rates; the implications for the dose-response relationships for health effects at low doses; and thus the relevance for estimating associated risks to health as well as the relevance for the inference of cancer risks. An expert group was established

[4] *Effects of Ionizing Radiation: United Nations Scientific Committee on the Effects of Atomic Radiation 2006 Report to the General Assembly*, vol. II (United Nations publication, Sales No. E.09.IX.5), annex E ("Sources-to-effects assessment for radon in homes and workplaces").

that submitted progress reports to the Committee for consideration at its sixty-fourth, sixty-fifth and sixty-sixth sessions.

12. At its sixty-sixth session, the Scientific Committee discussed the draft manuscript prepared by the expert group, which had conducted substantial scientific literature searches and assessed the literature against an evaluation system based on annex A to the UNSCEAR 2017 report.[5] The Committee considered the preparation of similar quality guidelines for the review of publications on biological mechanisms related to addressing the mechanisms of radiation effects.

13. The Scientific Committee's report will address mechanisms of radiation actions and biological reactions relevant for the inference of cancer risk after low-dose exposure. Given the well-advanced status of the draft report, the Committee expects to be able to consider a mature draft with a view to approval at its sixty-seventh session.

2. Assessments of human exposure to ionizing radiation

14. The Scientific Committee took note of the progress report by the secretariat on the collection, analysis and dissemination of data on radiation exposures of the public, patients and workers, obtained from reviews of the scientific literature and the data submissions by Member States. The Committee recognized the efforts of the secretariat in: (a) conducting outreach about the global surveys, which has contributed to an increased number of nominations of national contact persons; and (b) fostering the production of a simplified questionnaire to assist in the preparation of data submissions, which has had a positive impact on the number of submissions. As at 30 April 2019, 87 countries had nominated national contact persons (compared with 74 in 2018). Although this is a significant increase in participation, more contributions would be useful in view of the fact that there are 193 States Members of the United Nations. The Committee has therefore extended its deadline for data submission until 30 September 2019.

15. The Scientific Committee expressed its continued support for the creation of a network of national contact persons, using the UNSCEAR online platform as a tool for communication among them for exchanging experiences on the process of data collection. It also encouraged States Members of the United Nations to provide data on medical, occupational and public exposure and encouraged continued future cooperation of the Committee's secretariat with States Members of the United Nations and relevant international organizations.

(a) Medical exposure to ionizing radiation

16. Given that radiation exposures of patients worldwide are the main artificial source of human exposure to ionizing radiation, that there has been a continuing upward trend in collective doses to populations, and that the pace of technological development in this field continues to accelerate, the Scientific Committee's regular evaluations of collective doses to populations and trends continue to be an important priority.

17. As at 30 April 2019, 53 countries had submitted data on medical exposures, and the Scientific Committee recognized the efforts of the expert group in carefully and systematically reviewing the submitted data and working with national contact persons to clarify any ambiguities. As a number of Member States notified the Committee that they had additional or updated data, the Committee decided to extend the deadline for data collection until 30 September 2019 to accommodate them. The Committee also asked the secretariat to continue its outreach to national contact persons, especially in low- and middle-income countries, during this period to encourage further submissions.

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[5] *Sources, Effects and Risks of Ionizing Radiation: United Nations Scientific Committee on the Effects of Atomic Radiation 2017 Report to the General Assembly* (United Nations publication, Sales No. E.18.IX.1), annex A ("Principles and criteria for ensuring the quality of the Committee's reviews of epidemiological studies of radiation exposure").

18. The Scientific Committee provided guidance to the expert group on a number of technical and editorial issues and noted the importance of completing the analysis of the data in order to have the technical document submitted for approval at its sixty-seventh session.

(b) Occupational exposure to ionizing radiation

19. The Scientific Committee's evaluations of worldwide occupational exposure to ionizing radiation provide information relevant for policy and decision-making regarding the use and management of radiation. The resulting dose distributions and trends give insight into the main sources and situations of exposure and provide information about the main factors influencing exposures. The evaluations assist in identifying emerging issues and may indicate situations that should be subjected to more attention and scrutiny.

20. The Scientific Committee has conducted evaluations of worldwide occupational exposure and trends on the basis of two sources: (a) data from the UNSCEAR Global Survey of Occupational Radiation Exposures; and (b) reviews of analyses conducted and published by others. With respect to the first source, by 30 April 2019, 50 countries (compared with 39 in 2018) had submitted data for occupational exposures. With respect to the second source, a systematic review of more than 700 articles identified about 300 as applicable to the evaluation. Because a number of Member States notified the Committee that they had additional or updated data, the Committee decided to extend the deadline for data collection until 30 September 2019 to accommodate them.

21. The Scientific Committee acknowledged the efforts of the expert group in conducting its systematic review of the literature and provided guidance to the group on a number of technical and editorial issues. The Committee noted the importance of completing the analysis of the data in order to have the technical document submitted for approval at its sixty-seventh session.

(c) Public exposure to ionizing radiation

22. The Scientific Committee recalled the sixty-fourth session, at which the proposal to evaluate public exposure to ionizing radiation had been discussed. The Committee decided at that time to postpone project initiation until its evaluation on lung cancer from exposure to radon had been completed. At its sixty-sixth session, the Committee decided to commence its evaluation of public exposure to ionizing radiation.

23. The exposure of the public to artificial sources in the environment (including potential accidents) are of considerable interest to Governments and civil society. The most significant database in this regard is the database on Discharges of Radionuclides to the Atmosphere and the Aquatic Environment (DIRATA), developed by the International Atomic Energy Agency (IAEA).[6] With regard to any future assessment of public exposure from discharges, the Scientific Committee noted that the secretariat held preliminary discussions with IAEA to explore methods of updating and using the datasets for its evaluation of public exposure to ionizing radiation.

(d) Levels and effects of radiation exposure due to the accident at the Fukushima Daiichi nuclear power station: implications of information published since the UNSCEAR 2013 report

24. At its sixty-fifth session, the Scientific Committee considered the project plan to produce an update to annex A to the UNSCEAR 2013 report.[7] The aim was to

[6] See https://dirata.iaea.org. The database includes information on atmospheric and aquatic discharges of radionuclides from nuclear and non-nuclear facilities, where available, and has interfaces for the entry, editing, interrogation and reporting of data.

[7] *Sources, Effects and Risks of Ionizing Radiation: United Nations Scientific Committee on the Effects of Atomic Radiation 2013 Report to the General Assembly*, vol. I (United Nations publication, Sales No. E.14.IX.1), annex A ("Levels and effects of radiation exposure due to the nuclear accident after the 2011 Great East Japan Earthquake and tsunami").

produce a report setting out a summary of all information available, up to the end of 2019, on levels and effects of radiation exposure due to the accident at the Fukushima Daiichi nuclear power station, and the implications of the new information for the UNSCEAR 2013 Fukushima report.

25. At its sixty-sixth session, the Scientific Committee discussed the draft document prepared by the expert group. The Committee endorsed the more focused scope of the detailed analyses of doses to the public and concurred that the outreach material on issues of considerable media or public interest should be dealt with separately, as part of the secretariat's outreach plan. The Committee expected that the technical document would be submitted to the Committee at its sixty-seventh session with a view to its approval.

3. Second primary cancer after radiotherapy

26. At its sixty-third session, the Scientific Committee considered the issue of second primary cancer after radiotherapy and discussed preliminary plans to launch a project based on a proposal by the French delegation. After further discussions at the sixty-fourth session, the Committee reached agreement at its sixty-fifth session on a project plan to evaluate second primary cancer after radiotherapy, emphasizing that while the project was a priority, the work could not be started until after the appointment of the new Secretary.

27. At its sixty-sixth session, the Scientific Committee took note of a progress report on the project. That report included an update on the actions taken by the secretariat to establish an expert group that will commence work in the third quarter of 2019. The evaluation will summarize the current state of knowledge regarding second primary cancer frequency and risk, considering out-of-field dosimetry and epidemiological findings, as well as genomic and molecular sciences. The final report will also include a summary written in language that should be understood by members of the public. In the first year, the group will begin to review the literature, applying the principles and quality criteria for epidemiological studies as published in annex A to the UNSCEAR 2017 report and the literature review process established by the secretariat. The expert group will provide a progress report, including a first selection of literature evaluated on second primary cancer after radiotherapy, an updated timetable and an advanced table of contents, for discussion by the Committee at its sixty-seventh session.

4. Epidemiological studies of radiation and cancer

28. At its sixty-third session, the Scientific Committee discussed a preliminary plan to provide a comprehensive scientific review of epidemiological studies of radiation and cancer to update annex A to the UNSCEAR 2006 report.[8] The Committee agreed at its sixty-fifth session to initiate the comprehensive scientific review after both the appointment of the new Secretary and the initiation of the project on second primary cancer after radiotherapy.

29. At its sixty-sixth session, the Scientific Committee approved the project, the results of which will provide experts, decision makers, the scientific community, civil society and national and international organizations with up-to-date scientific information on cancer risk following exposure to ionizing radiation. It will also provide a sound basis for informed decision-making on radiation-related issues. The final report will also include a summary written in language that should be understood by members of the public.

30. The expert group will commence work in the third quarter of 2019. The group will begin to review the literature, applying the principles and quality criteria for epidemiological studies as published in annex A to the UNSCEAR 2017 report and

[8] *Effects of Ionizing Radiation: United Nations Scientific Committee on the Effects of Atomic Radiation 2006 Report to the General Assembly*, vol. I (United Nations publication, Sales No. E.08.IX.6), annex A ("Epidemiological studies of radiation and cancer").

the literature review process established by the secretariat. The expert group will provide a progress report, including a first selection of literature evaluated on epidemiological studies on radiation and cancer, an updated timetable and an advanced table of contents, for discussion by the Scientific Committee at its sixty-seventh session.

5. Public information and outreach strategy (2020–2024)

31. At its sixty-sixth session, the Scientific Committee took note of a progress report of the secretariat on the implementation of outreach activities in the 2014–2019 period and endorsed the secretariat's proposal for a new strategy on outreach activities for the 2020–2024 period. The latter complements the secretariat's planned outreach activities on the update of annex A to UNSCEAR 2013 report on the levels and effects of radiation exposure due to the accident at the Fukushima Daiichi nuclear power station.

32. The Scientific Committee welcomed the online publication of the updated UNEP booklet *Radiation: Effects and Sources* (which is intended as information for the public) in all the official languages of the United Nations, and in five other languages as well. It encouraged the secretariat to further translate and promote the publication.

33. The Scientific Committee noted that the General Assembly encouraged the secretariat to continue to disseminate its findings and reports to the public. The Committee suggested that future work should be focused on the development of information material based on published UNSCEAR reports and should address specific topics, such as exposure due to radon or the follow-up of the radiological consequences of the Chernobyl accident. The Committee encouraged the secretariat to further enhance the UNSCEAR website. The Committee noted that the dissemination of the Committee's findings and further enhancements to the UNSCEAR website would depend on the financial and human resources made available to the secretariat.

C. Update on the Committee's long-term strategic directions

34. The Scientific Committee recalled that at its sixty-third session, it had considered its long-term strategic directions beyond the period covered by its present strategic plan (2014–2019) and had envisaged directing its future work in specific scientific areas. It also recalled the possible need to implement a range of strategies that would support its efforts to serve the scientific community as well as wider audiences. Those strategies were foreseen to include:

(a) Establishing working groups focused on sources and exposure, or effects and mechanisms;

(b) Increasing the Scientific Committee's efforts to present its evaluations, and summaries thereof, in a manner that attracts readers without compromising scientific rigour and integrity;

(c) Liaising closely with other relevant international bodies to avoid duplication of efforts to the extent possible, while maintaining its lead in providing authoritative scientific evaluations to the General Assembly.

35. At its sixty-sixth session, the Scientific Committee reviewed and updated the terms of reference of its Bureau and its long-term strategic directions to reflect (a) the establishment of the ad hoc working group on sources and exposure and (b) the prolongation of the activities of the ad hoc working group on effects and mechanisms until its sixty-seventh session in 2020.

(a) Establishing working groups focused on areas of sources and exposure, and effects and mechanisms

36. At its sixty-fifth session, the Scientific Committee endorsed the establishment of an ad hoc working group on effects and mechanisms as a trial to assist the Bureau in developing a future programme of work on mechanisms and effects of radiation exposure for 2020–2024 by providing recommendations based on their scientific insights in the Committee's priority areas. The working group successfully prepared the proposal for the future programme of work of the Committee (2020–2024), which was discussed by the Committee at its sixty-sixth session. The Committee also decided to extend the mandate of the working group for another year to support the Bureau in following up developments in science and new information relevant to the implementation of the Committee's programme of work.

37. At its sixty-sixth session, the Scientific Committee also endorsed the establishment of a second ad hoc working group on sources and exposure following the experience of the ad hoc working group on effects and mechanisms. The working group will consist of individual expert scientists selected for their competence, commitment and objectivity.

38. The Scientific Committee emphasized that, except for the administrative support from the secretariat, the establishment of the ad hoc working groups and their methods of work will be provided cost-free to the United Nations.

(b) Inviting, on an ad hoc basis, scientists from other States Members of the United Nations to participate in evaluations regarding the above areas

39. The Scientific Committee noted that the secretariat and the Bureau had taken steps to involve scientists from other States Members of the United Nations in supporting the secretariat in conducting ongoing evaluations. The Committee noted the support of Norway in the preparation of the report entitled "Lung cancer from exposure to radon", approved by the Committee at its sixty-sixth session.

(c) Increasing the Committee's efforts to present its evaluations, and summaries thereof, in a manner that attracts readers without compromising scientific rigour and integrity

40. The Scientific Committee referred to the outreach activities reported under section B.5 above.

(d) While maintaining its lead in providing authoritative scientific evaluations to the General Assembly, liaising closely with other relevant international bodies to avoid duplication of efforts

41. The importance of the Scientific Committee's findings in providing the scientific evidence upon which decisions are made by the international community and safety standards developed was also demonstrated in the period since the sixty-fifth session. For example, the UNSCEAR 2012 report was considered by the IAEA Commission on Safety Standards to determine its possible impact on radiation protection standards. In addition, the preparation of the upcoming report of the Secretary-General highlighted the importance of the Committee's scientific evaluation for the Inter-Agency Task Force on Chernobyl.[9]

42. The Scientific Committee welcomed and supported the continued future cooperation of the secretariat with United Nations and other international organizations[10] with a view to promoting the Committee's work and exploring

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[9] See http://chernobyl.undp.org/english/partners.shtml.

[10] For example, UNEP, IAEA, the Nuclear Energy Agency of OECD, the Inter-Agency Committee on Radiation Safety, the International Radiation Protection Association, the International Commission on Radiological Protection and International Commission on Radiation Units and Measurements.

synergies and joint activities that will contribute to that work and support the collection and analysis of scientific data.

D. Future programme of work

43. At its sixty-fifth session, the Scientific Committee established the ad hoc working group on effects and mechanisms. Since the sixty-fifth session, the ad hoc working group has collected and analysed the experience of and lessons learned by the Committee in recent years and developed a draft programme of work for the 2020–2024 period that was presented to the Committee at its sixty-sixth session. The ad hoc working group also supported the Bureau in further developing the project proposals on (a) second primary cancer after radiotherapy and (b) epidemiological studies of radiation and cancer.

44. During its sixty-sixth session, the Scientific Committee considered a draft programme of work for the 2020–2024 period and agreed that very high priority should be given to starting a study on diseases of the circulatory system. The Committee discussed several other high-priority topics, and reached agreement on priorities to be considered in the future, subject to the completion of ongoing projects and further literature reviews. With regard to the topic of acute radiation sickness directly attributable to high radiation exposure and the possible long-term consequences, the Committee requested that the scope of the topic be reviewed and expanded. Further updates by the ad hoc working group on those topics will be considered during the sixty-seventh session.

45. The Scientific Committee also acknowledged the proposals for development of an UNSCEAR glossary in the future. It emphasized that the programme implementation depended on available resources in the secretariat and asked the Secretary to consider how the secretariat would implement the future programme of work.

E. Administrative issues

46. The Scientific Committee took note of General Assembly resolution 73/261 on the effects of atomic radiation, in which the Assembly:

(a) Noted with concern the developments which resulted in the request by the Scientific Committee at its sixty-fifth session to the Office of Internal Oversight Services to conduct: (i) an investigation or inspection into the process to recruit the Scientific Secretary to ensure that the successful candidate is selected on the basis of scientific qualifications and credibility and that the process is aligned with Article 101, paragraph 3, of the Charter of the United Nations; and (ii) an internal audit or evaluation to clarify whether UNEP is the most appropriate body to serve the Committee in the future;

(b) Requested UNEP to continue, within existing resources, to service the Committee and to disseminate its findings to Member States, the scientific community and the public and to ensure that the administrative measures in place are appropriate, including clear roles to efficiently service the Committee in a predictable and sustainable manner and effectively facilitate the use of the invaluable expertise offered to the Committee by its members in order that the Committee may discharge the responsibilities and mandate entrusted to it by the General Assembly;

(c) Regretted that the UNEP secretariat had not appointed a new Secretary of the Committee in a timely manner, thereby jeopardizing continuity in the Committee secretariat, and insists that all steps to be taken to ensure such continuity and that any ongoing selection process is expedited and managed in a transparent manner;

(d) Requested the Secretary-General to strengthen support for the Committee within existing resources, particularly with regard to the deputization of the Secretary of the Committee, the avoidance of disruptions in staffing and the increase to operational costs in the case of a further increase in membership, and to report to the General Assembly at its seventy-fourth session on these issues.

47. In considering the requests of the General Assembly, the Scientific Committee recalled the negative impact that the delay in the Secretary's recruitment had had on the Committee's work and recalled that the Committee had requested the United Nations Office of Internal Oversight Services in New York to investigate the recruitment procedure and whether UNEP was the most appropriate body to serve the Committee in the future. The Committee noted that the investigation of the recruitment was in the past and that, with the appointment of the new Secretary, it had an opportunity to make a fresh start. The Committee welcomed the upgrading of the post of Scientific Officer to Deputy Secretary.

48. The Scientific Committee noted that it was important to learn from the lessons of the previous few years and to make every effort not to repeat such situations in future. In particular, the Committee must be more involved in the appointment of a new Secretary and should be fully involved in the evaluation of the written assessments in order to be sure that the candidate has the scientific expertise required of the role of Secretary. The Committee also noted that there should be a timely closure of the process. In this context, it was noted that the Committee had been without a Secretary for more than one year, which had caused serious problems, and that better administrative support should be provided by UNEP to cover management agreements, administrative procedures and channels of communication. If these had been in place, the previous problems would have been less serious.

49. The Scientific Committee noted the statement by the representative of UNEP, who recalled the substance of resolution 73/261 as set out in paragraph 46 (b)–(d) above, noting that UNEP had engaged with the Chair of the Committee through the three rounds of recruitment and that the United Nations rules and procedures had been followed, with a focus on gender balance. The Committee welcomed the assurance of UNEP that the new post of Deputy Secretary would soon be announced and that the Programme was ready to support the Committee and the secretariat with a number of activities, such as the collection of data by taking over the DIRATA database from IAEA in the coming months and outreach activities.

50. The Scientific Committee agreed to hold its sixty-seventh session in Vienna from 13 to 17 July 2020.

Chapter III

Scientific reports

51. Two scientific annexes, on the evaluation of selected health effects and inference of risk due to radiation exposure and on lung cancer from exposure to radon, provide the rationale for the findings expressed below. The Scientific Committee discussed the use of "effective dose" for the purpose of its scientific evaluations.

52. The Scientific Committee noted that in 1982 it had informed the General Assembly that its reporting would differ from previous reports in one important aspect: instead of estimating the absorbed doses to only a limited number of important tissues, the Committee would combine the doses in all organs and tissues in an expression of dose called the "effective dose equivalent", which the Committee believed to better represent the whole risk incurred by the exposed populations.[11] The effective dose equivalent (now known as "effective dose") is a quantity that was introduced by the International Commission on Radiological Protection for radiation protection purposes and is used worldwide in radiation protection standards. The Committee intends to reconsider the appropriateness of continuing employing this quantity for discharging its own functions while it also uses the concept of "absorbed dose".

A. Evaluation of selected health effects and inference of risk due to radiation exposure

53. Following on from the UNSCEAR 2012 report, annex B,[12] the Scientific Committee more thoroughly addressed the various sources of uncertainty involved in risk estimation for specific scenarios with exposure to ionizing radiation. The scenarios were chosen to be relevant for present-day exposure situations of different exposed groups and ages, and to represent, as far as possible, the conditions of recent large epidemiological studies. The estimation of risk was based on rates of disease that have been observed in the past.

54. The Scientific Committee decided at its sixty-third session that it would be essential to have an expert estimation of the knowledge of risk based on published studies for five combinations of health effects and conditions of exposures to ionizing radiation: (a) leukaemia incidence after CT scans in childhood; (b) leukaemia mortality after occupational exposure; (c) mortality from all solid cancers after occupational exposure; (d) thyroid cancer incidence after ^{131}I intake during childhood; and (e) cardiovascular disease mortality after exposure to external radiation. The objective was to perform quantitative risk evaluations of health effects in specific exposure situations with low-to-moderate doses for cancer and in situations with higher doses for circulatory diseases.

55. At its sixty-sixth session, the Scientific Committee reviewed and approved the annex on evaluation of selected health effects and inference of risk due to radiation exposure. The Committee concluded the following:

(a) In annex B to the UNSCEAR 2012 report, the Committee addressed more thoroughly the various sources of uncertainty involved in the estimation of risk for specific scenarios with exposure to ionizing radiation. The scenarios were chosen to be relevant for present-day exposure situations of different exposed groups and ages, and to correspond as far as possible to the conditions of recent large epidemiological studies. The estimation of risk was based on rates of disease that have been observed

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[11] See *Official Records of the General Assembly, Thirty-seventh Session. Supplement No. 45* (A/37/45).

[12] *Sources, Effects and Risks of Ionizing Radiation: United Nations Scientific Committee on the Effects of Atomic Radiation 2012 Report to the General Assembly* (United Nations publication, Sales No. E.16.IX.1), annex B ("Uncertainties in risk estimates for radiation-induced cancer").

in the past. In the context of radiation-related health effects, risk refers to the probability that an event of interest (e.g., onset of cancer) will occur (i.e., it is prospective) during a given time period (e.g., the rest of life following an exposure). As an example, for the leukaemia scenarios different ages were selected for exposure and follow-up . The scenario for children starts with exposure at age 1, and a 30-year follow-up selected, as that is the time span for which there is sufficient information to calculate credible intervals. In the scenario for adults, as a result of similar restrictions in available data, follow-up of the exposure starts at age 30 and ends at age 60;

(b) The Committee calculated risks with two approaches for the combinations of cancer risk. The first was based on the recent epidemiological study that was simulated by the scenario, the other on effects observed in the life span study of survivors of the atomic bombings of Hiroshima and Nagasaki. All known sources of uncertainties were discussed. Confidence intervals were calculated, disregarding those sources of uncertainties for which there was not sufficient information for a rigorous quantification. Conclusions were derived for two different conditions. First, for conditions for which there is a wealth of information, the results of the two approaches agree well, confirming that effects observed in the life span study may be transferred to other situations. However, for these specific conditions the recent epidemiological studies have a higher precision and reliability. Second, for other conditions the information content of the recent studies was limited. Dependencies of radiation-related effects on age at exposure, dose and period of follow-up could not be quantified. The life span study remains a main source of information. It has to be kept in mind, however, that the scientific basis for estimating uncertainties involved in the transfer of the effect observed in the study to other populations is limited;

(c) The Committee judged the size of all known sources of uncertainty in the estimation of health risks for conditions for which there is a wealth of information in recent studies. Some parameters, for example the development of disease rates in the future, are not known. In order to allow predictions to be made, assumptions were nevertheless made for those parameters. A Monte Carlo method to estimate the impact of the known uncertainties was used to establish a credible interval of the "preferred risk inference";[13]

(d) For the assessment of radiation risk of leukaemia and myelodysplastic syndromes in children and young adults, baseline incidence rates were assumed to be the same as in the United Kingdom of Great Britain and Northern Ireland during the period 2011–2013. CT scans at age 1, with a total absorbed dose to the red bone marrow of 20 mGy, were estimated to increase the baseline of 9 cases among 10,000 persons up to age 30 by about 5 cases with a 95 per cent credible interval from 0 to 20 cases. Observations in the life span study indicate that the risk of radiation-induced cases is (a) small beyond the attained age of 30; and (b) for age at exposure of 10 smaller than for age at exposure of 1 by a factor of about 5;

(e) In the assessment of radiation-induced leukaemia mortality among occupationally exposed workers, survival functions (the probability that a person will be alive after any specified time *t*) were assumed to be the same as in the United States of America in 2000, and baseline rates of mortality from leukaemia as those in the data from the Surveillance, Epidemiology and End Results programme of the National Cancer Institute for the period 2000–2005. For occupational exposures to external radiation at age 30 to 45 with a total absorbed dose to the red bone marrow of 200 mGy, the increase of the baseline of about 10 mortalities from leukaemia excluding chronic lymphocytic leukaemia[14] among 10,000 workers up to age 60 was estimated to be about 5 cases per 10,000 workers, with a 95 per cent credible interval from 1 to 10 mortalities. However, the baseline mortality from leukaemia increases

[13] The preferred risk inference is the one that best fits the characteristics of the considered scenario, based on an expert judgement on the magnitude of all the uncertainties associated with it.

[14] Chronic lymphocytic leukaemia is generally considered to be a non-radiogenic form of cancer.

steeply after the age of 60, and radiation-induced mortality is expected to increase, although the relative risk decreases with age;

(f) For the assessment of solid cancer, mortality data were taken from the same sources as for leukaemia. Occupational exposures to external radiation at age 30 to 45 with a total absorbed dose to the colon of 100 mGy were estimated to increase the baseline of about 230 mortalities from solid cancer among 10,000 workers up to age 60 by about 10 cases with a 95 per cent credible interval from 2 to 20 cases. The span of the credible interval by a factor of about 10 confirms an earlier estimation of the Committee in annex B to the UNSCEAR 2012 report. Confidence and trust in the range, however, had increased considerably by the time of the present study. As in the case of leukaemia, the baseline mortality from solid cancer increases steeply after the age of 60, and also radiation-induced mortality is expected to increase, although the relative risk decreases with age;

(g) Thyroid cancer after incorporation of ^{131}I may be influenced by factors like the amount of stable iodine present in drinking water. Nevertheless, in order to make an assessment of the risk, the Committee assumed those factors to be the same as in the Ukrainian-American study that was used to define the scenario. An intake of ^{131}I at age 10 with a total absorbed dose to the thyroid of 500 mGy was estimated to increase the baseline of about 3 cases per 10,000 persons by about 8 cases with a 95 per cent credible interval from 2 to 20 cases. For age at intake of 1, the number of radiation-related cases is assessed to be higher by a factor of about 2. Thyroid surveillance plays an important role in the number of detected thyroid cancer, and care has to be taken in transferring observations from a study to other populations;

(h) After exposures resulting in an absorbed dose below 1 Gy, much less is known about radiation-risks for cardiovascular diseases, as compared with cancer. Thus, the Committee used observations in the life span study to estimate risk in a scenario of a Japanese population exposed at age 30 to external radiation with an absorbed dose to the colon of 1.5 Gy. In addition to about 930 baseline mortalities per 10,000 persons from heart diseases up to age 90, the Committee assessed about 160 radiation-induced cases per 10,000 persons with a confidence interval from 30 to 300 cases. The Committee did not have enough information to judge the credible intervals that would have to take into account all known sources of uncertainty. The uncertainty of cerebrovascular mortality risk was even greater. These results are in line with the conclusions drawn in annex B to the UNSCEAR 2006 report;[15]

(i) Although much is known about radiation risks, considerable uncertainty remains regarding their quantification. In order to reduce that uncertainty, it is important to improve and continue epidemiological studies of health effects from exposures to ionizing radiation and to develop methods to quantify and combine the various sources of uncertainties.

B. Lung cancer from exposure to radon

56. At its sixty-sixth session, the Scientific Committee approved a document summarizing the findings of its scientific evaluation of lung cancer from exposure to radon and its decision regarding the dose conversion factor for radon exposure. The following was concluded:

(a) The Committee considered the issue of sources and effects of exposure to radon (^{222}Rn) and its progeny as well as thoron[16] (^{220}Rn) with regard to workers and the public and confirmed its previous conclusions that inhalation of radon and its

[15] *Effects of Ionizing Radiation: United Nations Scientific Committee on the Effects of Atomic Radiation 2006 Report to the General Assembly*, vol. I (United Nations publication, Sales No. E.08.IX.6), annex B ("Epidemiological evaluation of cardiovascular disease and other non-cancer diseases following radiation exposure").

[16] As thoron (^{220}Rn) dosimetry studies are limited and the absence of thoron epidemiological studies, the evaluation covered the dose conversion factor for radon (^{222}Rn) exposure.

decay products is carcinogenic mainly for the lungs and that doses to other organs and tissues were at least an order of magnitude smaller than the doses to the lungs;

(b) The Committee acknowledged in its previous evaluations that conversion factors for calculating the dose from a given exposure to radon (^{222}Rn) were needed for the following:

(i) For radiation protection purposes, which is in the mandate of other international bodies;

(ii) For comparison purposes with other sources of radiation exposure, which is related directly to the mandate of the Committee;

(c) Two approaches for deriving radon dose conversion factors are in use to express effects from exposure to radon. These are a "dosimetric approach", estimating the dose from a given exposure based on atmospheric conditions, breathing characteristics and lung modelling relevant for radon and its decay products; and an "epidemiological approach", based on using the ratio of the risk of lung cancer per unit radon exposure studied mostly in miners and the nominal risk related to effective dose of all cancers derived mostly from survivors of the atomic bombings;

(d) The Committee reviewed recent published dosimetry assessments for exposures in homes, indoor workplaces and mines and found for exposures in homes the range of the assessed effective doses per unit of exposure of equilibrium equivalent concentration (EEC) of ^{222}Rn are from 7 to 34 nSv per (h Bq m^{-3}) with an arithmetic mean of 18 nSv per (h Bq m^{-3}), and a geometric mean of 16 nSv per (h Bq m^{-3}). These values are consistent with those previously estimated by the Committee for average indoor conditions on the basis of dosimetric evaluations;

(e) The Committee also reviewed articles reporting on epidemiological studies (residential and occupational) of lung cancer risk from radon exposure published since 2006. For the residential studies, the excess relative risk estimates for lung cancer varied from −0.13 to 0.73 per 100 Bq m^{-3} for exposure to radon gas, with the mean excess relative risk of 0.13 per 100 Bq m^{-3};

(f) Occupational studies of miners published since 2006 were based mainly on extended follow-up of earlier cohort studies. Substantial variability in the excess relative risk estimates for lung cancer was observed in the updated occupational studies, with values ranging from 0.19 to 3.4 per 100 working level month (WLM),[17] without adjustment for modifying factors. Based on a statistical weighting procedure,[18] the combined excess relative risk estimated from the entire cohorts was 0.60 (95 per cent CI: 0.34, 0.87) per 100 WLM, in close agreement with the Committee's previous combined estimate of 0.59 (95 per cent CI: 0.35, 1.0) per 100 WLM in annex E to the UNSCEAR 2006 report. A higher combined excess relative risk estimate of 1.53 (95 per cent CI: 1.11, 1.94) per 100 WLM was obtained when restricting the analysis to more recent work periods and lower exposures. Preference was given to the latter estimate due to improved radon exposure assessments in more recent periods and to these radon exposures being more reflective of current mining conditions. However, this estimate is less precise due to smaller sample sizes;

(g) Residential and occupational risk estimates can be compared in a simple manner by converting a residential radon concentration to a cumulative exposure. The Committee's current estimate of lung cancer excess relative risk for residences of 0.16 per 100 Bq m^{-3}, adjusted for exposure uncertainty, can thus be expressed as 1.21 (95 per cent CI: 0.38, 2.35) per 100 WLM, an estimate which is between the previously stated combined risk estimate of 0.60 for the entire miner cohorts and 1.53 for combined subcohorts for more recent work periods. The risk of lung cancer

[17] A working level month refers to the exposure to one working level for 170 hours per month. A working level is the concentration of short-lived decay products of radon in equilibrium with 3,700 Bq/m^3 (100 pCi/L) in air.

[18] A random-effects meta-analysis with inverse-variance weighting.

from exposure to radon is not expected to be the same for residents and miners because of the different conditions under which they are exposed;

(h) A notable limitation of the combined estimates is that they ignore the modifying factors of exposure rate and attained age across studies, which reduce the comparability of individual results. In studies that did report on modifying factors, the lung cancer excess relative risk was observed to decrease with increasing attained age, with increasing time since exposure and with increasing exposure rate, albeit only for cumulative exposures above 50 to 100 WLM. Gender could not be investigated in the occupational studies as a modifying factor. It was concluded that models that included modifying factors were preferred for better comparability across studies and improved risk transfer to specific combinations of such factors;

(i) Lifetime risk was estimated by applying the BEIR VI[19] exposure-age-concentration model to selected Czech,[20] Wismut[21] and Eldorado[22] miner studies, where information was available, and the combined 11 miner studies used in the BEIR VI report. The estimates of lifetime excess absolute risk were 2.4 per 10,000 persons per WLM for the newly published large Wismut study, 3.9 for the updated Czech study and 7.5 for the updated Eldorado study. For the BEIR VI studies, the estimated lifetime excess absolute risk was 5.5 per 10,000 persons per WLM. The totality of this evidence is compatible with the Committee's previous assessment of lung cancer risk due to radon;

(j) Analyses of miner studies show largely a sub-multiplicative joint effect of radon and smoking on lung cancer risk. An assumption of synergistic effect of smoking and radon would mean that the lifetime absolute risk from radon would depend on the prevalence of smoking in the population: when the prevalence decreases, the risk decreases;

(k) Even though extensive research has been conducted on dosimetric and epidemiological evaluations, uncertainties remain large. The main uncertainties in the assessment of dose by using the dosimetric approach are due primarily to the uncertainty and variability of model parameter values and uncertainties associated with the assumptions built into the particular model, including over-simplification of the underlying processes. Both the miner studies and the residential studies of lung cancer risk from radon are subject to limitations arising mainly from uncertainties in estimates of radon exposure, particularly in early mining periods, and subject to confounding by other exposures, such as smoking. Limitations in evaluation of differences in risk across subgroups of the population include low precision due to small numbers of lung cancer cases among non-smokers, women and younger age groups. As outlined in the UNSCEAR 2012 report, annex B, on uncertainties in risk estimates for radiation-induced cancer, uncertainties are likely to underestimate excess relative risk estimates in studies of residential radon by 50 to 100 per cent. Since thoron and its decay products can be a significant component of the total exposure in some specific situations (workplaces or dwellings), it can be an additional source of error in radon studies that do not distinguish radon and thoron contributions

[19] National Research Council, Committee on Health Risks of Exposure to Radon, *Health Effects of Exposure to Radon,* BEIR Series, No. VI (Washington, D.C., National Academies Press, 1999).

[20] Based on a database established in 1969 with approximately 100,000 Czechoslovak uranium miners, the Czech cohort includes approximately 10,000 miners (4,364 miners first employed underground since 1948 for at least four years, and 5,625 miners first employed since 1969 for at least one year). The last report included 1,141 lung cancers observed in the cohort by 2010.

[21] The German Wismut cohort includes approximately 59,000 miners employed for at least six months between 1946 and 1989 at the Wismut uranium mining company in the former German Democratic Republic. The latest available information included 3,942 lung cancers observed in the cohort by 2013.

[22] The Canadian Eldorado cohort includes approximately 17,600 workers employed at the Beaverlodge mine between 1948 and the final shutdown of the mine in 1982, at the Port Radium uranium mine between 1942 and 1960, and at the Port Hope radium and uranium refining and processing between 1932 and 1980. The available information included 618 lung cancers observed in the cohort by 1999.

to the total exposure. Thoron contamination in radon measurements could have an impact on the assessment of lung cancer risk following radon exposure;

(l) Given that the uncertainties from both dosimetric and epidemiological studies give rise to a broad range of risk estimates and the fact that values from the current dosimetry and epidemiological reviews are consistent with those used in previous UNSCEAR reports, the Committee recommends the continued use of the dose conversion factor of 9 nSv per (h Bq m^{-3}) EEC of ^{222}Rn, which corresponds to 1.6 mSv (mJ h $m^{-3})^{-1}$ for estimating radon exposure levels to a population;

(m) The evidence reviewed by the Committee is compatible with the available data in the Committee’s previous assessment of lung cancer risk due to radon. Therefore, it is concluded that there is no reason to change the established dose conversion factor. The Committee will continue its general review of population exposure to radon, with a focus on the consequent risk of lung cancer.

Appendix I

Members of national delegations attending the sixty-third to sixty-sixth sessions of the United Nations Scientific Committee on the Effects of Atomic Radiation in the preparation of its scientific reports for 2019

Argentina	A. J. González (Representative), A. Canoba, P. Carretto, M. Ermacora, M. di Giorgio
Australia	G. Hirth (Representative), C.-M. Larsson (Representative), M. Grzechnik, C. Lawrence, P. Thomas, A. Wallace
Belarus	A. Razhko (Representative), A. Stazharau (Representative), A. Nikalayenka, L. Sheuchuk, V. Ternov
Belgium	H. Vanmarcke (Representative), S. Baatout, H. Bosmans, H. Engels, F. Jamar, L. Mullenders, H. Slaper, P. Smeesters, P. Willems
Brazil	L. Vasconcellos de Sá (Representative), J. G. Hunt (Representative), D. de Souza Santos
Canada	J. Chen (Representative), P. Thompson (Representative), J. Burtt, P. Demers, R. Lane, K. Sauvé, E. Waller, R. Wilkins
China	S. Liu (Representative), Z. Pan (Representative), L. Chen, L. Dong, T. Fang, D. Huang, Z. Lei, Y. Li, X. Lin, J. Liu, L. Liu, S. Liu, J. Mao, S. Pan, Q. Sun, X. Xia, M. Xu, S. Xu, D. Yang, F. Yang, H. Yang, X. Wu, G. Zhou, P. Zhou
Egypt	M.A.M. Gomaa (Representative), W. M. Badawy (Representative), T. M. Morsi
Finland	S. Salomaa (Representative), A. Auvinen, E. Salminen
France	L. Lebaron-Jacobs (Representative), J.-R. Jourdain (Representative), Y. Billarand, V. Blideanu, J.-M. Bordy, I. Clairand, C. Huet, A. Isambert, D. Laurier, K. Leuraud, F. Ménétrier, A. Rannou, M. Tirmarche
Germany	A. Friedl (Representative), P. Jacob (Representative), W. Weiss (Representative), S. Baechler, A. Böttger, K. Gehrcke, T. Jung, J. Kopp, M. Kreuzer, R. Michel, W.-U. Müller, C. Murith, W. Rühm, D. Wollschlaeger, H. Zeeb
India	A. Vinod Kumar (Representative), R. A. Badwe (Representative), K. S. Pradeepkumar (Representative), B. Das, A. Ghosh
Indonesia	N.R. Hidayati (Representative), Z. Alatas (Representative), E. Hiswara (Representative)
Japan	M. Akashi (Representative), Y. Yonekura (Representative), K. Akahane, S. Akiba, H. Fujita, R. Kanda, I. Kawaguchi, K. Kodama, M. Kowatari, K.Ozasa, S. Saigusa, K. Sakai, K. Tani, H. Yasuda, S. Yoshinaga
Mexico	J. Aguirre Gómez (Representative)
Pakistan	R. A. Khan (Representative), Z. A. Baig (Representative)
Peru	A. Lachos Dávila (Representative), B. García Gutérrez
Poland	M. Waligórski (Representative), L. Dobrzyński, M. Janiak, M. Kruszewski

Republic of Korea	B. S. Lee (Representative), M.-S. Jeong, J. K. Kang, D.-K. Keum, J.-I. Kim, K. P. Kim, J. K. Lee, J. E. Lee, S. W. Seo, K. M. Seong
Russian Federation	A. Akleev (Representative), T. Azizova, S. Geraskin, D. Ilyasov, V. Ivanov, L. Karpikova, S. Kiselev, A. Koterov, A. Kryshev, S. Mikheenko, S. Romanov, S. Shinkarev, R. Takhauov, V. Usoltsev, V. Uyba
Slovakia	L. Auxtová (Representative), M. Berčíková, A. Ďurecová, V. Jurina, K. Petrová, L. Tomášek
Spain	A. M. Hernández Álvarez (Representative), M. J. Muñoz González (Representative), M. T. Macías Domínguez, J. C. Mora Cañadas, E. Vañó Carruana
Sudan	R. O. A. Alfaki (Representative), N. A. Ahmed (Representative), I. I. Suliman
Sweden	I. Lund (Representative), E. Forssell-Aronsson, P. Hofvander, J. Lillhök, A. Wojcik
Ukraine	D. Bazyka (Representative)
United Kingdom of Great Britain and Northern Ireland	S. Bouffler (Representative), A. Bexon, R. Wakeford, W. Zhang
United States of America	E. V. Holahan Jr. (Representative), R. J. Preston (Representative), A. Ansari, L. R. Anspaugh, J. D. Boice Jr., W. Bolch, H. Grogan, N. H. Harley, B. A. Napier, D. Pawel, G. E. Woloschak

Appendix II

Scientific staff and consultants cooperating with the United Nations Scientific Committee on the Effects of Atomic Radiation in the preparation of its scientific reports for 2019

I. Apostoaei
A. Auvinen
J. Chen
K. Furukawa
C. Kaiser
D. Laurier
J. Marsh
W.-U. Müller
B. Smith
L. Tomášek

Members of the Committee's ad hoc working group on the effects of radiation exposure and the biological mechanisms by which they occur established at the sixty-fifth session

P. Jacob, Chair (Germany)
A. Auvinen, Rapporteur (Finland)
J. R. Jourdain (France)
L. Lebaron-Jacobs (France)
K. Ozasa (Japan)
K. M. Seong (Republic of Korea)
A. Akleev (Russian Federation)
S. Bouffler (United Kingdom)
D. Pawel (United States)

Secretariat of the United Nations Scientific Committee on the Effects of Atomic Radiation

B. Batandjieva-Metcalf (sixty-sixth session)

M. J. Crick (sixty-third and sixty-fourth sessions)

F. Shannoun (sixty-third to sixty-sixth sessions)