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Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed.
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Supplement to: Atun R, Jaffray DA, Barton MB, et al. Expanding global access to radiotherapy. *Lancet Oncol* 2015; **16**: 1153–86.

Appendix

Appendix_Table_Total Fractions per Country

	Country	Fractions needed 2012	Fractions needed 2035
1	Afghanistan	193,635	377,156
2	Albania	70,991	108,495
3	Algeria	396,422	789,379
4	Angola	109,837	242,902
5	Argentina	1,118,019	1,683,275
6	Armenia	109,609	136,850
7	Australia	1,135,711	1,827,967
8	Austria	380,251	518,175
9	Azerbaijan	143,165	230,180
10	Bahamas	9,549	19,062
11	Bahrain	8,337	23,283
12	Bangladesh	1,358,775	2,778,154

13	Barbados	13,057	18,432
14	Belarus	281,525	295,982
15	Belgium	639,005	838,718
16	Belize	3,853	9,962
17	Benin	48,633	109,226
18	Bhutan	4,257	8,606
19	Bolivia	107,109	197,636
20	Bosnia Herzegovina	96,932	120,559
21	Botswana	16,024	23,353
22	Brazil	4,731,625	9,055,889
23	Brunei Darussalam	5,244	14,886
24	Bulgaria	296,236	284,793
25	Burkina Faso	67,673	141,404
26	Burundi	75,508	168,700
27	Cambodia	129,246	296,707
28	Cameroon	151,281	301,554

29	Canada	1,718,369	2,727,467
30	Cape Verde	3,186	5,842
31	Central African Republic	28,393	51,046
32	Chad	61,785	124,996
33	Chile	360,580	726,147
34	China	24,761,218	44,180,986
35	Colombia	682,665	1,489,487
36	Costa Rica	84,507	195,879
37	Cote d'Ivoire	107,625	178,370
38	Croatia	208,645	242,949
39	Cuba	445,407	731,163
40	Cyprus	31,788	54,324
41	Czech Republic	518,317	702,064
42	Democratic People Republic of Congo	364,429	734,029
43	Democratic People Republic of Korea	489,734	724,872
44	Denmark	358,342	467,640

45	Djibouti	5,419	9,996
46	Dominican Republic	174,470	313,721
47	Ecuador	220,841	481,614
48	Egypt	868,532	1,521,614
49	El Salvador	87,084	131,724
50	Equatorial Guinea	5,287	10,333
51	Eritrea	28,576	73,882
52	Estonia	57,478	62,138
53	Ethiopia	532,978	1,144,703
54	Fiji	10,774	15,578
55	Finland	279,300	354,547
56	France (metropolitan)	3,799,465	4,972,843
57	Gabon	10,799	20,268
58	Georgia	136,132	148,383
59	Germany	4,663,651	5,660,624
60	Ghana	150,892	281,183

61	Greece	377,223	477,620
62	Guam	3,550	6,593
63	Guatemala	115,036	238,721
64	Guinea	49,839	105,031
65	Guinea-Bissau	7,578	14,793
66	Guyana	11,413	18,299
67	Haiti	84,267	148,770
68	Honduras	71,333	152,795
69	Hungary	464,356	519,614
70	Iceland	14,567	24,608
71	India	10,578,385	18,113,435
72	Indonesia	3,126,949	5,682,864
73	Iraq	249,488	589,254
74	Ireland	207,820	350,250
75	Islamic Republic of Iran	727,743	1,571,342
76	Israel	262,299	438,435

77	Italy	3,178,973	4,071,846
78	Jamaica	64,237	105,748
79	Japan	5,723,584	6,906,364
80	Jordan	57,643	148,474
81	Kazakhstan	401,613	578,348
82	Kenya	397,953	947,403
83	Kuwait	14,415	43,831
84	Kyrgyzstan	54,989	96,200
85	Lao People's Democratic Republic	36,561	73,397
86	Latvia	99,032	91,399
87	Lebanon	87,858	195,763
88	Lesotho	12,354	15,115
89	Liberia	18,686	39,888
90	Libya	57,953	124,040
91	Lithuania	130,277	127,348
92	Luxembourg	23,226	36,702

93	Macedonia	72,221	98,944
94	Madagascar	198,987	439,320
95	Malawi	131,971	266,904
96	Malaysia	395,057	784,307
97	Mali	86,760	174,798
98	Malta	17,730	26,893
99	Mauritania	16,717	38,047
100	Mauritius	25,709	44,016
101	Mexico	1,440,615	2,844,636
102	Moldova	90,975	93,964
103	Mongolia	23,410	48,473
104	Montenegro	20,637	23,149
105	Morocco	377,276	657,604
106	Mozambique	190,557	343,905
107	Myanmar	621,857	1,136,100
108	Namibia	12,626	23,212

109	Nepal	190,309	335,966
110	New Zealand	195,338	308,720
111	Nicaragua	52,648	108,214
112	Niger	52,077	127,282
113	Nigeria	1,094,849	2,057,829
114	Norway	274,223	409,580
115	Oman	12,106	39,583
116	Pakistan	1,542,308	2,882,863
117	Palestine	29,845	72,278
118	Panama	55,502	120,173
119	Papua New Guinea	64,047	129,257
120	Paraguay	87,713	165,749
121	Peru	404,136	798,382
122	Philippines	991,761	1,909,907
123	Poland	1,436,745	1,880,179
124	Portugal	466,498	601,556

125	Puerto Rico	115,549	154,659
126	Qatar	8,361	39,313
127	Republic of Congo	22,302	45,822
128	Republic of Korea	1,426,761	2,600,656
129	Romania	762,635	906,261
130	Russian Federation	4,038,425	4,358,833
131	Rwanda	74,413	177,472
132	Samoa	1,377	2,012
133	Saudi Arabia	147,684	379,042
134	Senegal	63,544	153,420
135	Serbia	415,118	448,108
136	Sierra Leone	25,439	47,842
137	Singapore	152,291	314,659
138	Slovakia	212,368	297,929
139	Slovenia	104,571	144,735
140	Solomon Islands	3,827	7,284

141	Somalia	77,207	151,945
142	South Africa	818,666	1,310,180
143	South Sudan	80,998	169,897
144	Spain	2,002,556	2,932,023
145	Sri Lanka	236,944	367,124
146	Sudan	197,369	407,532
147	Suriname	8,912	15,503
148	Swaziland	7,443	10,885
149	Sweden	516,540	656,062
150	Switzerland	408,014	620,177
151	Syrian Arab Republic	204,857	470,900
152	Tajikistan	50,814	117,354
153	Tanzania	344,714	753,585
154	Thailand	1,040,422	1,645,558
155	The Gambia	3,503	8,507
156	The Netherlands	911,967	1,256,306

157	Togo	32,372	63,278
158	Trinidad and Tobago	35,759	63,993
159	Tunisia	120,521	230,335
160	Turkey	1,341,247	2,641,377
161	Turkmenistan	59,821	105,150
162	Uganda	263,533	640,253
163	Ukraine	1,257,312	1,229,562
164	United Arab Emirates	27,234	136,357
165	United Kingdom	3,200,560	4,381,971
166	United States of America	15,407,178	22,834,608
167	Uruguay	129,333	169,679
168	Uzbekistan	233,914	424,712
169	Venezuela	454,388	868,227
170	Viet Nam	1,116,500	2,024,167
171	Yemen	110,227	230,283
172	Zambia	94,996	219,626

173	Zimbabwe	123,044	236,549
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Appendix for Sections VI

Appendix_Table {TAB_SABMParameters}: Resource data and operational parameters used in the activity-based model used for the L-MICs.

Input Parameters						Source
Resources						
Equipment	Number	Lifetime (years)	Investment Cost*	Annual maintenance	Annual amortization	
Linear accelerators, 3D-CRT capable single photon energy multi photon energy (including multi-leaf collimator and electronic portal imaging)	2	12	1,361,000 1,976,000	10%	8.3%	<i>model estimate</i>
CT-simulator (50% used for diagnostic purposes)	1	12	409,000	10%	8.3%	<i>model estimate</i>
3D-CRT treatment planning system (including up to 10 workstations)	1	5	272,000	10%	20%	<i>model estimate</i>

Record and Verify System	1	5	130,000	10%	20%	<i>model estimate</i>
High Dose Rate afterloader	1	12	545,000	10%	8.3%	<i>model estimate</i>
<i>Building</i>	<i>m²</i>	<i>Lifetime (years)</i>	<i>Investment Cost*</i>	<i>Annual maintenance</i>	<i>Annual amortization</i>	
Total square meters	1463	30	2,280,746	2%	3.3%	<i>IAEA manual [1]</i>
LINAC bunkers	282		568,004			
simulation area	192		257,818			
treatment planning area	140		187,992			
brachytherapy	189		380,684			
<i>Personnel</i>	<i>Number</i>		<i>Training cost per person*</i>	<i>Annual Salary per FTE*</i>	<i>Working hours</i>	
RO	5		100,000	37,200	8	<i>model computation survey</i>
MP	4		50,000	20,100	8	<i>model computation survey</i>
RTT	13		28,000	9,060	8	<i>model computation survey</i>

DO	3		39,000	14,580	8	<i>model computation</i> <i>survey</i>
RN	1		28,000	8,640	8	<i>model estimate</i> <i>survey</i>
Engineers	2		33,350	13,400	8	<i>model estimate</i> <i>survey</i>
Overhead						
% added to all resource costs	20%					<i>model estimate</i>
Operational parameters						
Daily operating hours	12					<i>model estimate</i>
Working days per week	5					<i>model estimate</i>
Shifts per day	1,5					<i>model estimate</i>
RTTs per shift	3					<i>model estimate</i>
average fractions per course	18,35					<i>computation WP IV</i>
annual courses per LINAC	570					<i>model computation</i>

<i>Time estimates (3D-CRT)</i>	<i>Time</i> <i>(minutes, per activity)</i>	<i>RO</i>	<i>MP</i>	<i>RTT</i>	<i>DO</i>	
Treatment preparaton						<i>IAEA staff estimator [2]</i>
immobilisation	15-30 min			15-30 min		
3D simulation	30 min	6 min	15 min	30 min x 2 RTT	3 min	
GTV-CTV delineation	60 min	60 min				
OAR delineation	60 min				60 min	
PTV definition	30 min				30 min	
treatment planning	150 min		38 min		112 min	
plan approval	15 min	15 min				
Treatment delivery						<i>IAEA staff estimator [2]</i>
plan sim verification	30 min	6 min		30 min x 2 RTT		
first set-up	18 min			18 min x 3 RTT		
portal imaging (weekly)	6 min			6 min x 3 RTT		
fraction treatment delivery	15 min			15 min x 3 RTT		
chart check (weekly)	12 min	5 min	12 min	5 min		

clinical follow-up (weekly)	15 min	15 min				
<i>Time estimates (brachytherapy)</i>	<i>Time</i> <i>(minutes, per activity)</i>	<i>RO</i>	<i>MP</i>	<i>RTT</i>	<i>RN</i>	
Insertion applicators	60 min	60 min			60 min	<i>IAEA staff estimator [2]</i>
3D simulation	30 min		15 min	30 min		
Treatment planning	120 min	84 min	72 min			
Treatment delivery	30 min	30 min	30 min	30 min		
Applicators removal-patient recovery	60 min	30 min			60 min	
<i>Time estimates equipment QA**</i>	<i>Time</i> <i>(annual hours)</i>					
MV single energy	400					<i>IAEA staff estimator [2]</i>
MV multiple energy	1050					
MLC						
EPID	250					
3D-CRT TPS (10 workstations)	250					
R&V network						
High Dose Rate afterloader	600					

	750					
	500					
Non-RT related activities		RO	MP	RTT	DO	
Percentile time devoted to non-RT activities, such as follow-up after treatment, tumour boards, administration, teaching, R&D, ...		40%	20%	5%	5%	<i>model estimate</i>

The input values in this example apply to L-MIC.

- model estimates are based on a consensus among GTFRCC participants
- required FTEs of RO, MP, RTT and DO were computed through the activity-based approach, FTE of nurses and engineers were consensus-based.
- equipment costs are an agreed average, based on input from various available sources
- salaries and training costs were derived from survey data and corrected with data from LABORSTA, a database of labour statistics operated by the International Labour Organization .

*Cost values and salaries are in USD for the year 2013.

**Equipment QA is assumed to be performed outside working hours by MPs and engineers.

[1] Radiotherapy Facilities: Master Planning and Concept Design Considerations. <http://www.pub-iaea.org/MTCD/Publications/PDF/Pub1645web-46536742.pdf>

[2] IAEA RO staffing calculator

<http://nucleus.iaea.org/HHW/RadiationOncology/Makingthecaseforradiotherapyinyourcountry/Roleofradiotherapyincancercare/Radiot herapyisacosteffectivesystemwhich needsabalance/index.html>

Table {TAB_SensSpecSABM_CapEx}: Sensitivity analysis in the operational costs, CapEx, allows for improved efficiency, longer treatment hours per day, and bulk purchasing savings. The combination of all three results in approximately 50% operating costs savings in the LIC and MIC countries. These can be applied alone or in concert. Operating cost savings are presented in [Sections 6&7](#).

CapEx – Sensitivity Analysis			GNI			
Automation – Efficiency	Longer Hours	Bulk Purchase	HIC	U-MIC	L-MIC	LIC
X	-	-	-22%	-19%	-19%	-19%
-	X	-	-18%	-22%	-22%	-22%
-	-	X	-11%	-16%	-16%	-16%
X	X	-	-35%	-36%	-36%	-37%
-	X	X	-26%	-33%	-34%	-34%
X	-	X	-30%	-32%	-32%	-32%
X	X	X	-41%	-45%	-46%	-46%