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Abemaciclib plus a nonsteroidal aromatase inhibitor as initial therapy for HR+, HER2-advanced breast cancer: Final overall survival results of MONARCH 3

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PII: S0923-7534(24)00139-X

DOI: <https://doi.org/10.1016/j.annonc.2024.04.013>

Reference: ANNONC 1472

To appear in: *Annals of Oncology*

Received Date: 6 March 2024

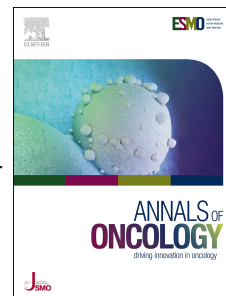
Revised Date: 29 April 2024

Accepted Date: 30 April 2024

Please cite this article as: Goetz MP, Toi M, Huober J, Sohn J, Trédan O, Park IH, Campone M, Chen SC, Manso LM, Paluch-Shimon S, Freedman OC, O'Shaughnessy J, Pivot X, Tolaney SM, Hurvitz S, Llombart-Cussac A, André V, Saha A, van Hal G, Shahir A, Iwata H, Johnston SRD, Abemaciclib plus a nonsteroidal aromatase inhibitor as initial therapy for HR+, HER2- advanced breast cancer: Final overall survival results of MONARCH 3, *Annals of Oncology* (2024), doi: <https://doi.org/10.1016/j.annonc.2024.04.013>.

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1 **Article type:** original article

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3 **Abemaciclib plus a nonsteroidal aromatase inhibitor as initial therapy for**
4 **HR+, HER2- advanced breast cancer: Final overall survival results of**
5 **MONARCH 3**

6

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35 **Prior presentation:** This work was presented in part at San Antonio Breast Cancer Symposium

36 46th Annual Meeting (Dec 6th, 2023, San Antonio, TX, USA).

37 **Short title:** Overall survival with abemaciclib + NSAI as initial therapy for HR+, HER2- ABC

38

39 **Highlights**

- 40 1. This phase 3 trial evaluated abemaciclib + NSAI versus placebo + NSAI as initial therapy
41 for HR+, HER2- ABC.
- 42 2. Addition of abemaciclib to an NSAI resulted in numerically longer OS; however,
43 statistical significance was not reached.
- 44 3. Absolute improvement in median OS was clinically meaningful (ITT: 13.1 months; sVD:
45 4.9 months).
- 46 4. The previously demonstrated PFS benefit with the addition of abemaciclib was sustained
47 (median improvement 14.3 months).
- 48 5. The addition of abemaciclib delayed subsequent receipt of chemotherapy (median
49 improvement 16.1 months).

50

51

52 Abstract

53 **Background:** In MONARCH 2, the addition of abemaciclib to fulvestrant significantly
54 improved both progression-free survival (PFS) and overall survival (OS) in patients with HR+,
55 HER2- advanced breast cancer (ABC) with disease progression on prior endocrine therapy (ET).
56 In MONARCH 3, the addition of abemaciclib to a nonsteroidal aromatase inhibitor (NSAI) as
57 initial therapy for HR+, HER2- ABC significantly improved PFS. Here, we present the
58 prespecified final OS results for MONARCH 3.

59 **Patients and Methods:** MONARCH 3 is a randomized, double-blind, phase 3 study of
60 abemaciclib plus NSAI (anastrozole or letrozole) versus placebo plus NSAI in postmenopausal
61 women with HR+, HER2- ABC without prior systemic therapy in the advanced setting. The
62 primary objective was investigator-assessed PFS; OS was a gated secondary endpoint, and
63 chemotherapy-free survival (CFS) was an exploratory endpoint.

64 **Results:** A total of 493 women were randomized 2:1 to receive abemaciclib plus NSAI ($n = 328$)
65 or placebo plus NSAI ($n = 165$). After a median follow-up of 8.1 years, there were 198 OS
66 events (60.4%) in the abemaciclib arm and 116 (70.3%) in the placebo arm (hazard ratio, 0.804;
67 95% confidence interval [CI], 0.637-1.015; $P = 0.0664$, non-significant). Median OS was 66.8
68 versus 53.7 months for abemaciclib versus placebo. In the subgroup with visceral disease (sVD),
69 there were 113 OS events (65.3%) in the abemaciclib arm and 65 (72.2%) in the placebo arm
70 (hazard ratio, 0.758; 95% CI, 0.558-1.030; $P = 0.0757$, non-significant). Median OS was 63.7
71 months versus 48.8 months for abemaciclib versus placebo. The previously demonstrated PFS
72 benefit was sustained, and CFS numerically improved with the addition of abemaciclib. No new
73 safety signals were observed.

74 **Conclusion:** Abemaciclib combined with an NSAI resulted in clinically meaningful
75 improvement in median OS (ITT: 13.1 months; sVD: 14.9 months) in patients with HR+ HER2-
76 ABC; however, statistical significance was not reached.

77 **Keywords:** overall survival; abemaciclib; CDK4/6 inhibitor; first-line therapy; HR-
78 positive/HER2-negative; advanced breast cancer

79 INTRODUCTION

80 Hormone receptor-positive (HR+), human epidermal growth factor receptor 2-negative (HER2-)
81 breast cancer is the most prevalent breast cancer subtype (approximately 70% of all breast
82 cancers),¹ and metastatic disease remains incurable. The majority of patients with HR+ HER2-
83 advanced breast cancer (ABC) treated with aromatase inhibitors (AIs) in the first-line setting will
84 experience disease progression/recurrence within approximately 15 months.²⁻⁴ Thus, alternative
85 therapies that synergize with endocrine therapy (ET) are needed to improve patient survival.

86 Cyclin-dependent kinase (CDK) 4/6 inhibitors in combination with ET have improved outcomes
87 for patients with HR+, HER2- ABC and have become a standard treatment option on the basis of
88 prolonged progression-free survival (PFS).^{5,6} Abemaciclib is an oral, selective CDK4/6 inhibitor
89 with greater selectivity for CDK4 than CDK6, which, unlike other currently approved CDK4/6
90 inhibitors, allows continuous dosing due to less myelosuppression.⁷ Abemaciclib has
91 demonstrated efficacy as monotherapy and in combination with AIs/fulvestrant in ABC in the
92 MONARCH trials^{2,8-10} and also in combination with ET in node-positive, high-risk early breast
93 cancer (EBC) in the monarchE trial,¹¹ which has led to regulatory approvals in both the
94 metastatic and adjuvant settings.

95 In the absence of cure, improvement in overall survival (OS) remains an important goal for
96 patients with ABC. In MONARCH 2, the addition of abemaciclib to fulvestrant significantly
97 improved both PFS and OS in patients with HR+, HER2- ABC with disease progression on prior
98 ET.^{8,12} MONARCH 3 is a phase 3 trial evaluating abemaciclib in combination with a
99 nonsteroidal aromatase inhibitor (NSAI) in postmenopausal women with HR+, HER2- ABC who
100 have not received prior systemic therapy in the advanced setting. The primary objective was
101 previously met with the results showing significantly prolonged PFS with the addition of

102 abemaciclib versus placebo to NSAI (median, 28.2 months versus 14.8 months; hazard ratio,
103 0.540; 95% confidence interval [CI], 0.418-0.698; $P = 0.000002$).² At the last interim OS
104 analysis (5.8-year follow-up), a numerically favorable median OS difference of 12.6 months was
105 observed (hazard ratio, 0.754; 95% CI, 0.584-0.974; $P = 0.0301$, non-significant).¹³ Here, we
106 report the results of the prespecified final OS analysis of MONARCH 3.

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107 METHODS

108 Procedures

109 MONARCH 3 is a global, randomized, double-blind, placebo-controlled, phase 3 study
110 evaluating abemaciclib with an NSAI versus placebo with an NSAI in postmenopausal women
111 with HR+, HER2- ABC who have not received prior systemic therapy in the advanced setting.
112 The NSAI selected was anastrozole or letrozole per physician's choice. Prior ET in the
113 neoadjuvant or adjuvant setting was permitted if the patient had a disease-free interval >12
114 months from the completion of ET. This study was conducted in 158 centers in 22 countries.
115 Eligible patients were randomized in a 2:1 ratio to receive abemaciclib or placebo (150 mg twice
116 daily continuous schedule) plus either 1 mg anastrozole or 2.5 mg letrozole daily. Cycles were
117 28 days. Stratification factors included metastatic site (visceral, bone only, other) and prior
118 (neo)adjuvant ET (AI, other, none). The presence of visceral disease refers to lung, liver, pleural,
119 peritoneal, or adrenal gland involvement at the time of randomization. Additional study details
120 were previously reported.¹⁰
121 This study was funded by the sponsor, Eli Lilly and Company, and designed together with the
122 steering committee. The study was performed in compliance with the Declaration of Helsinki.
123 The study protocol and amendments were approved by the relevant ethical and institutional
124 review boards and all patients gave written informed consent.

125 Patients

126 Women ≥ 18 years of age with locally tested HR+, HER2- breast cancer, postmenopausal status,
127 locoregionally recurrent disease not amenable to resection or radiation therapy with curative
128 intent, or metastatic disease were eligible. Patients must have had measurable disease or non-

129 measurable bone-only disease, as defined by RECIST v1.1, in addition to adequate organ
130 function and an Eastern Cooperative Oncology Group (ECOG) performance status (PS) score of
131 ≤ 1 .

132 Patients with visceral crisis, lymphangitic spread, leptomeningeal carcinomatosis, inflammatory
133 breast cancer, or evidence or history of central nervous system metastasis were excluded. Prior
134 CDK4/6 inhibitor or systemic therapy for advanced disease was not permitted.

135 **Endpoints**

136 The primary endpoint was investigator-assessed PFS, defined as the time from randomization
137 until progressive disease or death. OS, a key secondary endpoint, was assessed from time of
138 randomization until death. Chemotherapy-free survival (CFS), an exploratory endpoint, was
139 defined as time from randomization to initiation of first post-discontinuation chemotherapy or
140 death. Efficacy and safety measures have been previously described.¹⁰ Adverse events (AEs)
141 were graded according to the National Cancer Institute Common Terminology Criteria, version
142 4.0, and coded by MedDRA.

143 **Statistical Analysis**

144 All efficacy analyses were performed on the intent-to-treat (ITT) population, which included all
145 randomized patients, and all safety analyses were performed in patients who received at least one
146 dose of abemaciclib, placebo, or NSAI.

147 With 240 PFS events, the study was powered to 80% with a 2-sided alpha of 5% assuming a
148 hazard ratio of 0.67 in favor of the abemaciclib arm. No power assumptions were made for the
149 secondary endpoint of OS. A gate-keeping hierarchical strategy between the primary PFS and
150 secondary OS endpoints was used to control the overall familywise 2-sided type I error rate at

151 5%, such that OS was to be tested only if PFS was statistically significant. The alpha of 0.05 was
152 split between the ITT population and the subgroup with visceral disease (sVD) using a graphical
153 approach, with an initial allocation of 0.04 for the ITT population and 0.01 for the sVD. The
154 cumulative type I error rate within each population was maintained using the Lan-DeMets
155 spending function with O'Brien-Fleming boundary used to control multiplicity for all the interim
156 and final analyses. The final OS analysis was to be performed after observing approximately 315
157 events. For this final OS analysis, based on the actual number of events observed, the 2-sided *P*-
158 value boundary was 0.034 for the ITT population and 0.009 for the sVD.

159 The Kaplan-Meier method was used to estimate survival curves. OS of the treatment groups was
160 compared in the ITT population using a stratified log-rank test and in the sVD using an
161 unstratified log-rank test. Cox proportional hazards (PH) model was used to estimate the
162 treatment effect hazard ratio between the abemaciclib plus NSAI arm and the placebo plus NSAI
163 arm. The inverse probability of censoring weights (IPCW) method was prespecified as a
164 sensitivity analysis and used to evaluate the impact of follow-up systemic therapy with other
165 CDK4/6 inhibitors on OS.¹⁴ The IPCW method involved (a) censoring patients in both arms at
166 the time of initiation of additional post-progression CDK4/6 inhibitor treatment and (b)
167 determining appropriate weights for each subject at risk at each censoring timepoint using a Cox
168 PH model. The variables to be used as weights for the model were selected from a set of
169 prespecified covariates including demographics and baseline disease characteristics: race, age
170 group, geographical region, baseline ECOG PS, disease extent at study entry, prior (neo)adjuvant
171 ET, nature of disease, progesterone receptor status, and number of organs involved. The final
172 IPCW-adjusted treatment effect was estimated using a weighted Cox PH model. SAS version 9.4

173 (SAS Institute) and R version 4.2.2 (R Foundation for Statistical Computing) were used for
174 statistical analyses.

175 RESULTS

176 Patients

177 Between November 18, 2014, and November 11, 2015, 493 patients were randomly assigned 2:1
178 to receive abemaciclib plus an NSAI ($n = 328$) or placebo plus an NSAI ($n = 165$) (Figure 1). At
179 the final OS cut-off (September 29, 2023), a total of 23 (7.0%) patients in the abemaciclib arm
180 and 5 (3.0%) patients in the placebo arm continued to receive study treatment. The majority
181 (79.1%) of patients received letrozole. Baseline patient and disease characteristics were well
182 balanced between treatment arms (Table S1). A total of 263 (53.3%) patients had visceral
183 disease. Overall, 196 (39.8%) patients had de novo metastatic breast cancer and 297 (60.2 %)
184 patients had locoregional or metastatic recurrent breast cancer. A total of 231 (46.9%) patients
185 had received prior (neo)adjuvant ET (including 135 [27.4%] who had received prior AI therapy)
186 and 191 (38.7%) patients had received prior (neo)adjuvant chemotherapy.

187 Overall Survival

188 At the cut-off for this final OS analysis with a median follow-up of 8.1 years, 314 OS events had
189 occurred among 493 patients in the ITT population (abemaciclib arm, $n = 198$ [60.4%]; placebo
190 arm, $n = 116$ [70.3%]). The hazard ratio for death was 0.804 (95% CI, 0.637-1.015; $P = 0.0664$).

191 The threshold for statistical significance was not reached.

192 Median OS was 66.8 months in the abemaciclib arm and 53.7 months in the placebo arm, an
193 absolute difference of 13.1 months in the ITT population (Figure 2). The 5- and 6-year OS rates

194 were 54.5% versus 42.1% and 45.7% versus 35.2%, respectively, for abemaciclib versus
195 placebo.

196 Consistent OS effect sizes were observed across prespecified subgroups, including patients who
197 had de novo and recurrent metastatic disease (Figure 3). In subgroup analyses, the hazard ratios
198 for the abemaciclib arm versus the placebo arm were consistent across subgroups with respect to
199 prognosis and endocrine sensitivity, with a numerically greater effect observed in patients with
200 bone-only disease, progesterone receptor–negative tumors, or prior AI therapy.

201 In the sVD, 178 OS events had occurred among 263 patients (abemaciclib arm, $n = 113$ [65.3%];
202 placebo arm, $n = 65$ [72.2%]). The hazard ratio for death was 0.758 (95% CI, 0.558-1.030; $P =$
203 0.0757). The threshold for statistical significance was not reached. Median OS was 63.7 months
204 in the abemaciclib arm and 48.8 months in the placebo arm, an absolute difference of 14.9
205 months in the sVD (Figure 2). The 5- and 6-year OS rates were 50.1% versus 37.0% and 41.5%
206 versus 28.0%, respectively, for abemaciclib versus placebo.

207 **Post-Discontinuation Therapy**

208 Most patients who entered the post-treatment discontinuation follow-up received additional
209 therapies post-progression (Table 1). Across all lines of therapies post-progression, ETs were
210 most frequently reported (abemaciclib arm, 59.8%; placebo arm, 73.3%).

211 A total of 41.5% of patients in the abemaciclib arm and 61.8% in the placebo arm received
212 subsequent chemotherapy. CFS was prolonged with the addition of abemaciclib to NSAI (hazard
213 ratio, 0.693; 95% CI, 0.557-0.863; nominal $P = 0.0010$). Median CFS (including both
214 chemotherapy and death as events) was 46.7 months in the abemaciclib arm versus 30.6 months
215 in the placebo arm (absolute difference 16.1 months; Figure 4).

216 Subsequent targeted agents were received by 28.7% of patients in the abemaciclib arm and
217 48.5% in the placebo arm. Of note, a lower proportion of patients in the abemaciclib arm versus
218 the placebo arm received additional CDK4/6 inhibitor treatment in any subsequent line after
219 study treatment completion (abemaciclib arm, 11.6%; placebo arm, 31.5%). Among these
220 patients, the median time from randomization until initiation of the additional CDK4/6 inhibitor
221 treatment was 49.0 months in the abemaciclib arm and 33.0 months in the placebo arm. For
222 IPCW analysis, the censoring weights used to calculate the adjusted treatment effect were
223 derived based on the progesterone receptor status covariate, which was selected using a stepwise
224 variable selection procedure. The resulting hazard ratio for death for this sensitivity analysis was
225 0.772 (95% CI, 0.593-1.003; nominal $P = 0.0531$) in favor of the abemaciclib arm.

226 **Updated Investigator-Assessed Progression-Free Survival**

227 With a median follow-up of 8.1 years (additional 5.9 years from the final PFS analysis), the PFS
228 treatment effect is persistent. Consistent with results of the primary analysis, the updated PFS at
229 this final OS analysis was significantly improved by the addition of abemaciclib to NSAI (hazard
230 ratio, 0.535; 95% confidence interval, 0.429-0.668; nominal $P < 0.0001$) with a continued
231 separation of the curves. Median PFS was 29.0 months in the abemaciclib arm and 14.8 months
232 in the placebo arm (absolute difference 14.3 months; Figure 5).

233 **Safety**

234 The type, relative frequency, and severity of AEs remained consistent with those in previous
235 analyses (Table S2). The most common hematologic AEs graded 3 or higher in the abemaciclib
236 arm were neutropenia ($n = 90$ [27.5%]), anemia ($n = 31$ [9.5%]), and leukopenia ($n = 35$
237 [10.7%]). Diarrhea was the most frequent non-hematologic AE reported in the abemaciclib arm
238 but was predominantly low grade ($n = 273$ [83.5%] any grade; $n = 32$ [9.8%] grade ≥ 3). Diarrhea

239 cases were managed using medication or dose adjustments; treatment discontinuation due to
240 diarrhea remained infrequent (1.2%).

241 Interstitial lung disease/pneumonitis and venous thromboembolic events, including pulmonary
242 embolism and deep vein thrombosis, are clinically important AEs for abemaciclib and have
243 previously been described.¹⁵ Overall, there were 23 (7.0%) interstitial lung disease events in the
244 abemaciclib arm ($n = 5$ [1.5%] grade ≥ 3) versus 1 (0.6%) in the placebo arm (grade 2). A total of
245 25 (7.6%) venous thromboembolic events occurred in the abemaciclib arm ($n = 13$ [4.0%] grade
246 ≥ 3) versus 2 (1.2%) in the placebo arm ($n = 1$ [0.6%] grade ≥ 3).

247 DISCUSSION

248 In the MONARCH 3 trial, a clinically and statistically significant prolongation of PFS was seen
249 in postmenopausal women with HR+, HER2- ABC receiving initial therapy of abemaciclib and
250 NSAI.^{2,10} Endpoints based on tumor assessments, such as PFS, enable faster drug approvals and
251 access to patients, but it is important to confirm that the initially demonstrated PFS benefit
252 translates into a clinically meaningful improvement in OS. At this final OS analysis from
253 MONARCH 3 with a median follow-up of 8.1 years, although the results did not meet the
254 prespecified threshold for statistical significance in the ITT population (hazard ratio, 0.804; $P =$
255 0.0664) or the sVD (hazard ratio, 0.758; $P = 0.0757$), clinically meaningful improvements in
256 median OS were observed with the addition of abemaciclib to NSAI (ITT: 13.1 months; sVD:
257 14.9 months).

258 No new safety concerns were observed after this longer follow-up period and with prolonged
259 use of abemaciclib. Consistent with the findings of previous analyses, the most common AE
260 observed was low-grade diarrhea, which was effectively managed with antidiarrheal medications
261 and dose adjustments without risk of compromising efficacy. The combination of abemaciclib
262 plus NSAI continues to demonstrate an acceptable AE profile. The numerical OS improvement
263 combined with the sustained separation of the PFS curves and favorable safety profile reinforces
264 the use of this combination as first-line treatment for HR+, HER2- ABC.

265 In HR+ HER2- metastatic disease, the post-progression survival after first-line therapy is
266 relatively long, and patients often receive multiple lines of therapy during the metastatic disease
267 course.¹⁶ In this context, the OS assessment of first-line therapy can take years and potentially be
268 confounded by additional systemic therapies post-progression. In MONARCH 3, we hypothesize
269 that additional post-progression therapies, including CDK4/6 inhibitors, may have contributed to

270 the slight dilution of the OS effect observed beyond 6 years, consistent with the increased effect
271 size (hazard ratio, 0.772; $P = 0.0531$) from the prespecified sensitivity analysis adjusting for
272 CDK4/6 inhibitor use. Additionally, the greatest degree of separation between the OS curves is
273 observed prior to 6 years, as reflected by the hazard ratio of 0.754 observed at the MONARCH 3
274 second OS interim analysis with a median follow-up of 5.8 years.¹³ This numerically greater
275 effect size (compared to that observed at the final analysis at 8.1 years) corresponds to the hazard
276 ratio, which would have been obtained with a shorter follow-up of approximately 6 years, and
277 confirms the important impact of the timing of final analysis.

278 CDK4/6 inhibitors have transformed the treatment landscape of HR+, HER2- ABC in both the
279 first- and second-line setting and also the EBC setting and are included in clinical guidelines
280 such as NCCN and ABC5 with an ET partner as the preferred regimens in these settings.^{5,6}
281 However, inconsistencies have been observed between CDK4/6 inhibitors with respect to their
282 impact on OS. In the PALOMA-2 trial ($n = 666$; 2:1 randomization; 7.5 years median follow-
283 up), the addition of palbociclib versus placebo to letrozole did not lead to a statistically
284 significant improvement in OS, and the observed increase in median OS was 2.7 months (median
285 OS 53.9 versus 51.2 months).^{17,18} In the MONALEESA-2 trial ($n = 668$; 1:1 randomization; 6.6
286 years median follow-up), the addition of ribociclib versus placebo to letrozole demonstrated a
287 significant improvement in OS, with a median OS increase of 12.5 months (median OS 63.9
288 versus 51.4 months).¹⁹ In MONARCH 3, the addition of abemaciclib versus placebo to an NSAI
289 did not reach formal statistical significance, but the 13.1-month increase in median OS (median
290 OS 66.8 versus 53.7 months) was comparable to the 12.5-month improvement in median OS
291 observed in the MONALEESA-2 trial. These results show that ribociclib and abemaciclib both
292 led to a clinically meaningful median OS improvement, while the clinical relevance of the

293 observed median OS improvement for palbociclib is less clear. While recognizing the limitations
294 of cross-trial comparisons, it must be considered that there are important differences between
295 these studies with respect to design, size, and resulting statistical power. MONARCH 3 was the
296 smallest of the phase 3 CDK4/6 inhibitor studies in the first-line ABC setting, with a sample size
297 of 493 patients and a 2:1 randomization design.

298 The use of CDK4/6 inhibitors in the first-line setting for ABC was recently challenged by
299 findings from the SONIA trial, which showed no survival advantage of introducing CDK4/6
300 inhibitors in first-line treatment compared to second-line treatment.²⁰ Of note, 91% of the
301 patients enrolled in SONIA received palbociclib, which in contrast to abemaciclib and ribociclib,
302 has not shown a clinically meaningful or statistically significant difference in OS in the first- or
303 second-line ABC setting or an invasive disease-free survival (IDFS) benefit in the EBC
304 setting.^{17,18,21,22} While head-to-head comparisons of these three CDK4/6 inhibitors have not been
305 conducted, consistent differences in outcomes (OS and IDFS) have emerged across phase 3
306 studies of these therapies such that the results of the SONIA trial should not be extrapolated to
307 assume similar outcomes across this class of therapies. Furthermore, patients in the SONIA trial
308 received fulvestrant following a CDK4/6 inhibitor, the use of which as a single-agent is now
309 suboptimal in the second line, with newer, more effective alternatives available that target *ESR1*
310 mutations (eg, elacestrant) or PIK3CA/AKT signaling pathway alterations (either alpelisib or
311 capivasertib in combination with fulvestrant).²³⁻²⁵

312 Consistent OS effect size was seen across all subgroups in MONARCH 3, notably in patients
313 with the potential to have more comorbidities such as the elderly and those with an ECOG PS
314 score of 1, and also in those with bone-only and visceral disease. The latter is an interesting
315 finding considering no numerical effect was observed in patients with liver metastases with the

316 addition of ribociclib to letrozole in MONALEESA-2.²¹ Importantly, the effect size was
317 consistent in de novo and recurrent metastatic disease. It was previously reported that the benefit
318 of adding abemaciclib to either AI or fulvestrant appeared largest in patients with concerning
319 tumor characteristics, including progesterone receptor–negative tumors, and those with visceral
320 disease.²⁶ In this MONARCH 3 final OS analysis, the effect of abemaciclib was largest in
321 patients with prior AI therapy as well as those with progesterone receptor–negative disease.
322 These OS data are consistent with the findings in MONARCH 2, where the addition of
323 abemaciclib to fulvestrant resulted in a larger OS effect in patients with primary endocrine
324 resistance.¹²

325 Although the lack of statistical significance in this final OS analysis may be viewed as a
326 limitation of these data, it is important to consider the clinical relevance of the absolute effect
327 size in the context of the limitations of the study design, including the smaller sample size than
328 that in the PALOMA-2 and MONALEESA-2 studies, along with the body of consistent evidence
329 generated with abemaciclib across the first- and second-line ABC and EBC settings. MONARCH
330 3 is the third contemporary clinical trial investigating CDK4/6 inhibitors as first-line therapy in
331 postmenopausal patients to report final OS data. In addition to extent of follow-up and the
332 natural history of the disease during which patients receive multiple additional therapies, both
333 study size and randomization ratio impact the ability to prove statistical significance for OS.

334 Conclusions

335 Abemaciclib in combination with an NSAI resulted in numerically longer OS compared to NSAI
336 alone not only in the ITT population (median improvement 13.1 months), but also in patients
337 with visceral disease (median improvement 14.9 months) in postmenopausal women with HR+,
338 HER2- ABC in this pivotal phase 3 trial; however, statistical significance was not reached at this

339 final analysis. After a median follow-up of 8.1 years, the previously demonstrated PFS benefit
340 was sustained, median CFS was substantially improved, and no new safety signals were
341 observed. These data continue to support the consistent and meaningful clinical benefit
342 abemaciclib has demonstrated across the MONARCH program, including as adjuvant therapy in
343 node-positive, high-risk EBC, as initial therapy with AI for metastatic disease, in combination
344 with fulvestrant following disease progression, and as monotherapy in later lines of therapy.

345

346 Acknowledgements

347 We thank the patients and their caregivers for participating in the MONARCH 3 trial. We thank
348 the MONARCH study steering committee as well as the investigators and support staff who
349 generously participated in this trial. Writing support was provided by Maeve O’Connell, PhD, of
350 Eli Lilly and Company.

351 Funding

352 This work was supported by Eli Lilly and Company who sponsored the study and provided
353 support for medical writing assistance (no grant numbers apply).

354 Disclosure

355 MPG: Continuing medical education funding - Research to Practice, Clinical Educational
356 Alliance, Medscape, MJH Life Alliance; honoraria - Total Health Conferencing and Curio
357 Science; research funding (institute) - AstraZeneca, ATOSSA Therapeutics, Eli Lilly and
358 Company, Loxo@Lilly, Pfizer, Sermonix; consulting funding (institute) - ARC Therapeutics,
359 AstraZeneca, Biotheranostics, Blueprint Medicines, Loxo@Lilly, Novartis, Rna Diagnostics,
360 Sanofi, Seattle Genetics, Sermonix, Engage Health Media. MT: Grants or contracts (institute) -
361 Chugai, Takeda, Pfizer, Taiho, JBCRG assoc., KBCRN assoc., Eisai, Eli-Lilly and companies,
362 Daiichi-Sankyo, AstraZeneca, Astellas, Shimadzu, Yakult, Nippon Kayaku, AFI technology,
363 Luxonus, Shionogi, GL Science, Sanwa Shurui, Zene; Payment or honoraria for lectures -
364 Chugai, Takeda, Pfizer, Kyowa-Kirin, Taiho, Eisai, Daiichi-Sankyo, AstraZeneca, Eli Lilly and
365 companies, MSD, Exact Science, Shimadzu, Yakult, Nippon Kayaku Devicore medical Japan,
366 Sysmex; participation on advisory board - Daiichi-Sankyo, Eli Lilly and companies, Bertis,
367 Terumo, Kansai Medical Net; Associate Editor - British Journal of Cancer, Scientific Reports,

368 Breast Cancer Research and Treatment, Cancer Science. JH: Grants or contracts (institute) –
369 Lilly; consulting fees - Lilly, Novartis, Roche, Pfizer, AstraZeneca, Daiichi, Gilead; payment or
370 honoraria for lectures, presentations, speakers bureaus, manuscript writing or educational events
371 - Lilly, Novartis, Roche, Pfizer, AstraZeneca, Seagen, Gilead, Daiichi; travel support - Roche,
372 Novartis, Daiichi, Gilead. JS: Research grants (institute) – AstraZeneca, Boehringer Ingelheim,
373 Daiichi Sankyo, GSK, Lilly, MSD, Novartis, Pfizer, Roche, Sanofi. MC: Research grants
374 (institute) - Pfizer, Astrazeneca, Sanofi, Pierre Fabre, Takeda, Abbvie, ACCORD, Servier,
375 Sandoz; payment or honoraria for lectures, presentations, speakers bureaus, manuscript writing
376 or educational events - Novartis, Lilly. LMM: Speaker honoraria – Lilly. SP-S: Research grant
377 (institute) – Pfizer; consulting fees - Roche, Astrazeneca, Lilly, Novartis, Pfizer, Exact Sciences,
378 Gilead, MSD; Payment or honoraria for lectures, presentations, speakers bureaus, manuscript
379 writing or educational events - Roche, Astrazeneca, Lilly, Novartis, Pfizer, Exact Sciences,
380 Gilead, MSD. JOS: AbbVie Inc., Agendia, Amgen, Aptitude Health, AstraZeneca, BioNTech,
381 Beyondis, Carrick Therapeutics, Daiichi Sankyo, DAVA Oncology, Eisai, Fishawack Health, G1
382 Therapeutics, Genzyme, GlaxoSmithKline, Genentech, Gilead Sciences, Lilly, Loxo Oncology,
383 Merck, Novartis, Ontada, Pfizer, Pierre Fabre Pharmaceuticals, Puma Biotechnology, Roche,
384 Samsung Bioepis, Sanofi, Seagen, Stemline Therapeutics, Taiho Oncology, Very. SMT:
385 Honorarium for Consulting or Advisory Role - Novartis, Pfizer, Merck, Eli Lilly, AstraZeneca,
386 Genentech/Roche, Eisai, Sanofi, Bristol Myers Squibb, Seattle Genetics, CytomX Therapeutics,
387 Daiichi Sankyo, Gilead, OncXerna, Zymeworks, Zentalis, Blueprint Medicines, Reveal
388 Genomics, ARC Therapeutics, Infinity Therapeutics, Sumitovant Biopharma, Umoja Biopharma,
389 Artios Pharma, Menarini/Stemline, Aadi Bio, Bayer, Incyte Corp, Jazz Pharmaceuticals, Natera,
390 Tango Therapeutics, Systimmune, eFFECTOR, Hengrui USA; Research Funding (institute) -

391 Genentech/Roche, Merck, Exelixis, Pfizer, Eli Lilly, Novartis, Bristol Myers Squibb, Eisai,
392 AstraZeneca, NanoString Technologies, Gilead, Seattle Genetics, OncoPep, Daiichi Sankyo;
393 Travel support - Eli Lilly, Sanofi, Gilead. SH: Research grants or contracts - Ambrx, Amgen,
394 Arvinas, Astra Zeneca, Bayer, Boehringer-Ingelheim, Celcuity, Cytomx, Daiichi Sankyo,
395 Dantari, Eli Lilly, G1 Therapeutics, Genentech/Roche, Gilead, Greenwich Life Sciences,
396 Immunomedics, Loxo Oncology, MacroGenics, Medivation/Biomarin, Pfizer, Novartis, Orum,
397 Phoenix Molecular Design, PUMA, OBI Pharma, Sanofi, Seattle Genetics, Zymeworks, Jazz
398 Pharmaceuticals, Stemline/Menarini. AL-C: Research support - Roche, Agendia, Lilly, Pfizer,
399 Novartis, Merck Sharp&Dhome, Gilead, Daiichi Sankyo; consulting/advisor - Lilly, Roche,
400 Pfizer, Novartis; Speaker's Bureaus - Lilly, Astrazeneca, Merck Sharp&Dhome, Pfizer, Novartis;
401 travel support - Roche, Pfizer, Astrazeneca, Steamline therapeutics, Merck Sharp&Dhome. VA:
402 Stock ownership and employment – Lilly. AS: Stock ownership and employment – Lilly. GVH:
403 Stock ownership and employment – Lilly. AS: Stock ownership and employment – Lilly. HI:
404 Support for writing for the current manuscript – Lilly; grants or contracts – Chugai, Daiichi
405 Sankyo, AstraZeneca; consulting fees - Chugai, Daiichi Sankyo, AstraZeneca, Lilly, MSD,
406 Pfizer, Gilead; payment or honoraria for lectures/speakers bureaus - Chugai, Daiichi Sankyo,
407 AstraZeneca, Lilly, MSD, Pfizer, Taiho, Kyowa Kirin. SRDJ: Consulting fees – AstraZeneca, Eli
408 Lilly, Pfizer, Sanofi Genzyme; advisory board - AstraZeneca, Eli Lilly, Pfizer, Sanofi Genzyme;
409 Speakers' Bureaus – AstraZeneca. All other authors have declared no conflicts of interest.

410 REFERENCES

411

- 412 1. Surveillance, Epidemiology, and End Results (SEER) Program. Cancer Stat Facts: Female
413 Breast Cancer Subtypes. Available at: <https://seer.cancer.gov/statfacts/html/breast-subtypes.html>.
414 Accessed February 23, 2024.
- 415 2. Johnston S, Martin M, Di Leo A et al. MONARCH 3 final PFS: a randomized study of
416 abemaciclib as initial therapy for advanced breast cancer. *NPJ Breast Cancer* 2019; 5: 5.
- 417 3. Rugo HS, Finn RS, Dieras V et al. Palbociclib plus letrozole as first-line therapy in estrogen
418 receptor-positive/human epidermal growth factor receptor 2-negative advanced breast cancer
419 with extended follow-up. *Breast Cancer Res Treat* 2019; 174(3): 719-729.
- 420 4. Hortobagyi GN, Stemmer SM, Burris HA et al. Updated results from MONALEESA-2, a
421 phase III trial of first-line ribociclib plus letrozole versus placebo plus letrozole in hormone
422 receptor-positive, HER2-negative advanced breast cancer. *Ann Oncol* 2018; 29(7): 1541-1547.
- 423 5. Gradishar WJ, Moran MS, Abraham J et al. NCCN guidelines® insights: breast cancer,
424 version 4.2023. *J Natl Compr Canc Netw* 2023; 21(6): 594–608
- 425 6. Cardoso F, Paluch-Shimon S, Senkus E et al. 5th ESO-ESMO international consensus
426 guidelines for advanced breast cancer (ABC 5). *Ann Oncol* 2020; 31(12): 1623-1649.
- 427 7. Torres-Guzmán R, Ganado MP, Mur Perez C et al. Abemaciclib, a CDK4 and 6 inhibitor with
428 unique pharmacological properties for breast cancer therapy. *J Clin Oncol* 2021; 39(suppl 15):
429 e12506 [Abstract].
- 430 8. Sledge GW, Jr., Toi M, Neven P et al. MONARCH 2: abemaciclib in combination with
431 fulvestrant in women with HR+/HER2- advanced breast cancer who had progressed while
432 receiving endocrine therapy. *J Clin Oncol* 2017; 35(25): 2875-2884.
- 433 9. Dickler MN, Tolaney SM, Rugo HS et al. MONARCH 1, a phase II study of abemaciclib, a
434 CDK4 and CDK6 inhibitor, as a single agent, in patients with refractory HR(+)/HER2(-)
435 metastatic breast cancer. *Clin Cancer Res* 2017; 23(17): 5218-5224.
- 436 10. Goetz MP, Toi M, Campone M et al. MONARCH 3: abemaciclib as initial therapy for
437 advanced breast cancer. *J Clin Oncol* 2017; 35(32): 3638-3646.
- 438 11. Johnston SRD, Toi M, O’Shaughnessy J et al. Abemaciclib plus endocrine therapy for
439 hormone receptor-positive, HER2-negative, node-positive, high-risk early breast cancer
440 (monarchE): results from a preplanned interim analysis of a randomised, open-label, phase 3
441 trial. *Lancet Oncol* 2023; 24(1): 77-90.
- 442 12. Sledge GW, Toi M, Neven P et al. The effect of abemaciclib plus fulvestrant on overall
443 survival in hormone receptor-positive, ERBB2-negative breast cancer that progressed on
444 endocrine therapy—MONARCH 2: a randomized clinical trial. *JAMA Oncol* 2020; 6(1): 116-
445 124.

- 446 13. Goetz MP, Toi M, Huober J et al. MONARCH 3: interim overall survival (OS) results of
447 abemaciclib plus a nonsteroidal aromatase inhibitor (NSAI) in patients (pts) with HR+, HER2-
448 advanced breast cancer (ABC). *Ann Oncol* 2022; 33(suppl 7): S1384 [Abstract].
- 449 14. Robins JM, Finkelstein DM. Correcting for noncompliance and dependent censoring in an
450 AIDS clinical trial with inverse probability of censoring weighted (IPCW) log-rank tests.
451 *Biometrics* 2000; 56(3): 779-788
- 452 15. Rugo HS, Huober J, García-Sáenz JA et al. Management of abemaciclib-associated adverse
453 events in patients with hormone receptor-positive, human epidermal growth factor receptor 2-
454 negative advanced breast cancer: safety analysis of MONARCH 2 and MONARCH 3.
455 *Oncologist* 2021; 26(1): e53-e65.
- 456 16. Seidman AD, Maues J, Tomlin T, Bhatnagar V, Beaver JA. The evolution of clinical trials in
457 metastatic breast cancer: design features and endpoints that matter. *Am Soc Clin Oncol Educ*
458 *Book* 2020; 40: 1-11.
- 459 17. Finn RS, Rugo HS, Dieras VC et al. Overall survival (OS) with first-line palbociclib plus
460 letrozole (PAL+LET) versus placebo plus letrozole (PBO+LET) in women with estrogen
461 receptor-positive/human epidermal growth factor receptor 2-negative advanced breast cancer
462 (ER+/HER2- ABC): Analyses from PALOMA-2. *J Clin Oncol* 2022 40(17_suppl): LBA1003
463 [Abstract].
- 464 18. Slamon DJ, Diéras V, Rugo HS et al. Overall survival with palbociclib plus letrozole in
465 advanced breast cancer. *J Clin Oncol* 2024. January 22 [Epub ahead of print]
466 doi:10.1200/JCO.23.00137
- 467 19. Hortobagyi GN, Stemmer SM, Burris HA et al. Overall survival with ribociclib plus letrozole
468 in advanced breast cancer. *N Engl J Med* 2022; 386(10): 942-950.
- 469 20. Sonke GS, Van Ommen-Nijhof A, Wortelboer N et al. Primary outcome analysis of the phase
470 3 SONIA trial (BOOG 2017-03) on selecting the optimal position of cyclin-dependent kinases 4
471 and 6 (CDK4/6) inhibitors for patients with hormone receptor-positive (HR+), HER2-negative
472 (HER2-) advanced breast cancer (ABC). *J Clin Oncol* 2023 41(17_suppl): LBA1000
473 [Presentation Slides].
- 474 21. Turner NC, Slamon DJ, Ro J et al. Overall survival with palbociclib and fulvestrant in
475 advanced breast cancer. *N Engl J Med* 2018; 379: 1926-1936.
- 476 22. Gnant M, Dueck AC, Frantal S et al. Adjuvant palbociclib for early breast cancer: the
477 PALLAS trial results (ABCSG-42/AFT-05/BIG-14-03). *J Clin Oncol* 2022; 40(3): 282-293.
- 478 23. Bidard FC, Kaklamani VG, Neven P et al. Elacestrant (oral selective estrogen receptor
479 degrader) versus standard endocrine therapy for estrogen receptor-positive, human epidermal
480 growth factor receptor 2-negative advanced breast cancer: results from the randomized phase III
481 EMERALD trial. *J Clin Oncol* 2022; 40(28): 3246-3256.

- 482 24. André F, Ciruelos E, Rubovszky G et al. Alpelisib for PIK3CA-mutated, hormone receptor-
483 positive advanced breast cancer. *N Engl J Med* 2019; 380(20): 1929-1940.
- 484 25. Turner NC, Oliveira M, Howell SJ et al. Capivasertib in hormone receptor-positive advanced
485 breast cancer. *N Engl J Med* 2023; 388(22): 2058-2070.
- 486 26. Di Leo A, O'Shaughnessy J, Sledge GW Jr et al. Prognostic characteristics in hormone
487 receptor-positive advanced breast cancer and characterization of abemaciclib efficacy. *NPJ*
488 *Breast Cancer* 2018; 4: 41.

Journal Pre-proof

489 FIGURE CAPTIONS

490 **Figure 1.** CONSORT Diagram. *One patient who was randomized to placebo actually received
491 abemaciclib during cycle one. This patient is counted in the abemaciclib safety population.

492 NSAI, nonsteroidal aromatase inhibitor.

493 **Figure 2.** Kaplan-Meier Curves of Overall Survival in the (A) ITT Population and (B) Subgroup
494 with Visceral Disease. CI, confidence interval; ITT, intent-to-treat; NSAI, nonsteroidal aromatase
495 inhibitor.

496 **Figure 3.** Subgroup Analysis of Overall Survival. CI, confidence interval; HR, hazard ratio;
497 ECOG PS, Eastern Cooperative Oncology Group performance status.

498 **Figure 4.** Kaplan-Meier Curve of Chemotherapy-Free Survival in the ITT Population. CI,
499 confidence interval; ITT, intent-to-treat; NSAI, nonsteroidal aromatase inhibitor.

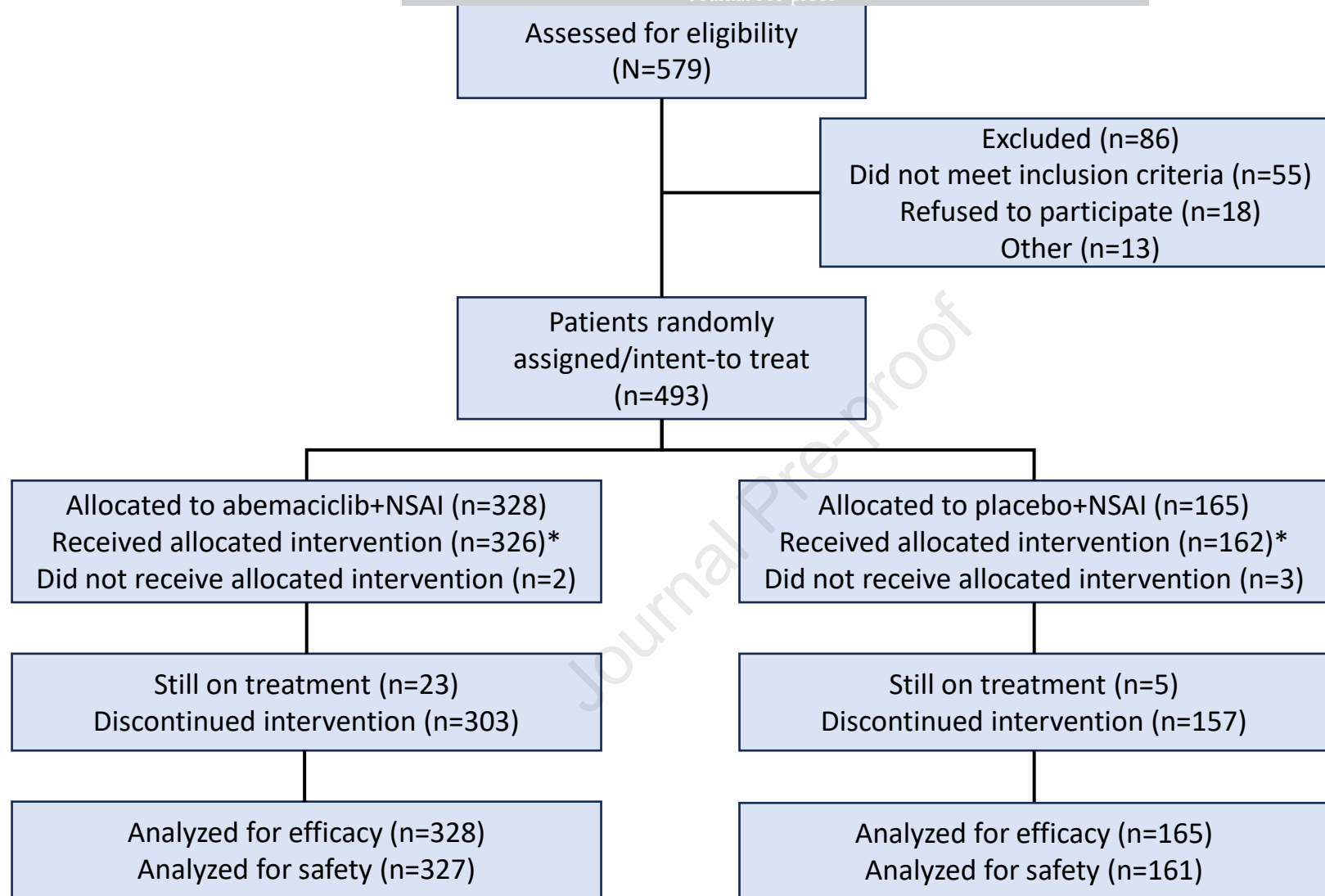
500 **Figure 5.** Kaplan-Meier Curve of Updated Progression-Free Survival in the ITT Population.

501 *The difference in median progression-free survival may differ due to rounding. ITT, intent-to-
502 treat; NSAI, nonsteroidal aromatase inhibitor.

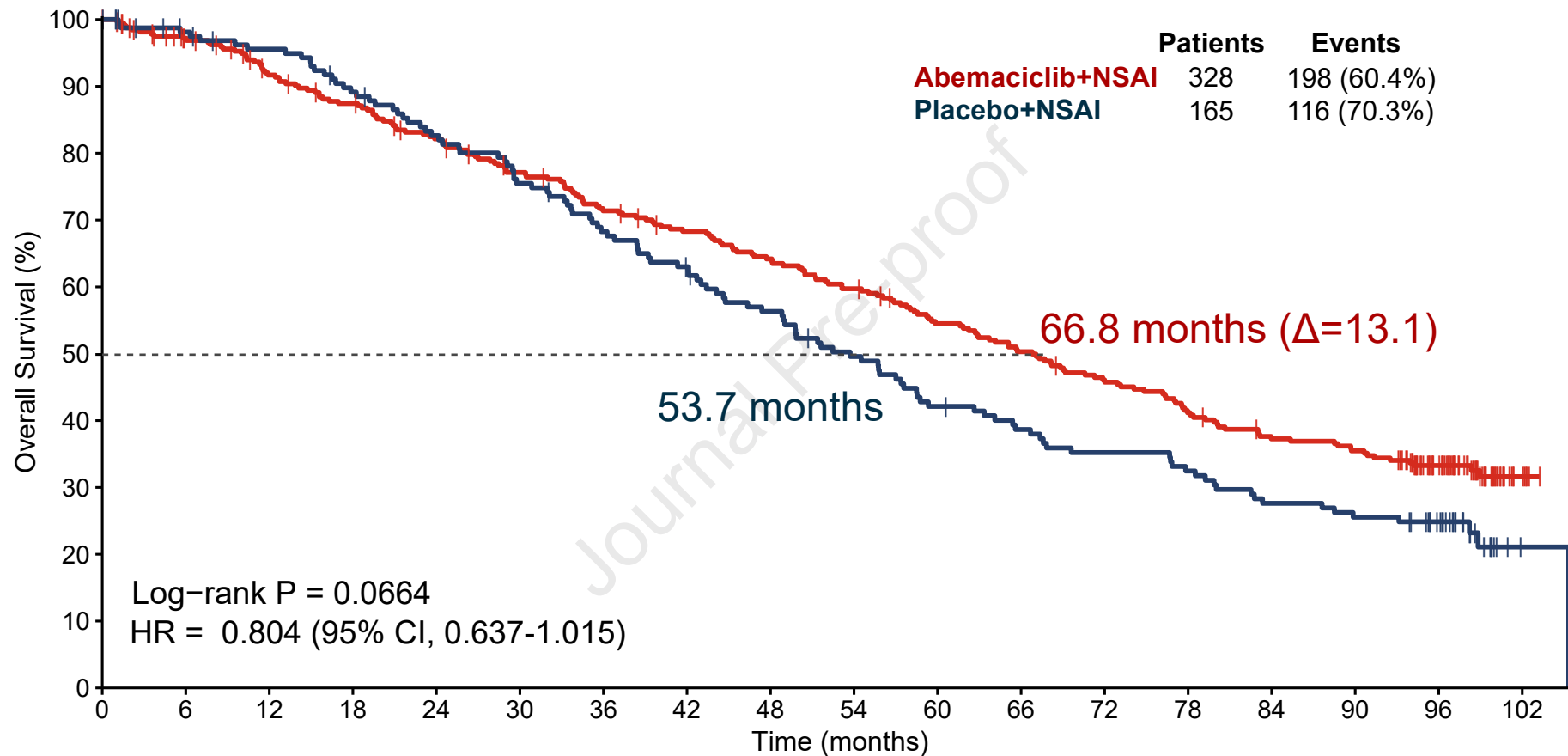
Table 1. Post-Discontinuation Therapy

Parameter, <i>n</i> (%)*	Abemaciclib + NSAI (<i>N</i> = 328)	Placebo + NSAI (<i>N</i> = 165)
Patients who received subsequent systemic therapy	234 (71.3)	142 (86.1)
Endocrine therapy	196 (59.8)	121 (73.3)
Chemotherapy	136 (41.5)	102 (61.8)
Targeted agent therapy	94 (28.7)	80 (48.5)
Other	39 (11.9)	29 (17.6)
Patients who received a CDK4/6 inhibitor in any subsequent line	38 (11.6)	52 (31.5)
Palbociclib	25 (7.6)	41 (24.8)
Abemaciclib	10 (3.0)	7 (4.2)
Palbociclib + abemaciclib	2 (0.6)	2 (1.2)
Ribociclib	1 (0.3)	2 (1.2)

*Denominator used to calculate % corresponds to ITT population. 284 (86.6%) in the abemaciclib arm and 154 (93.3%) in the placebo arm entered the post-treatment discontinuation follow-up. CDK, cyclin-dependent kinase; ITT, intent-to-treat; NSAI, nonsteroidal aromatase inhibitor.



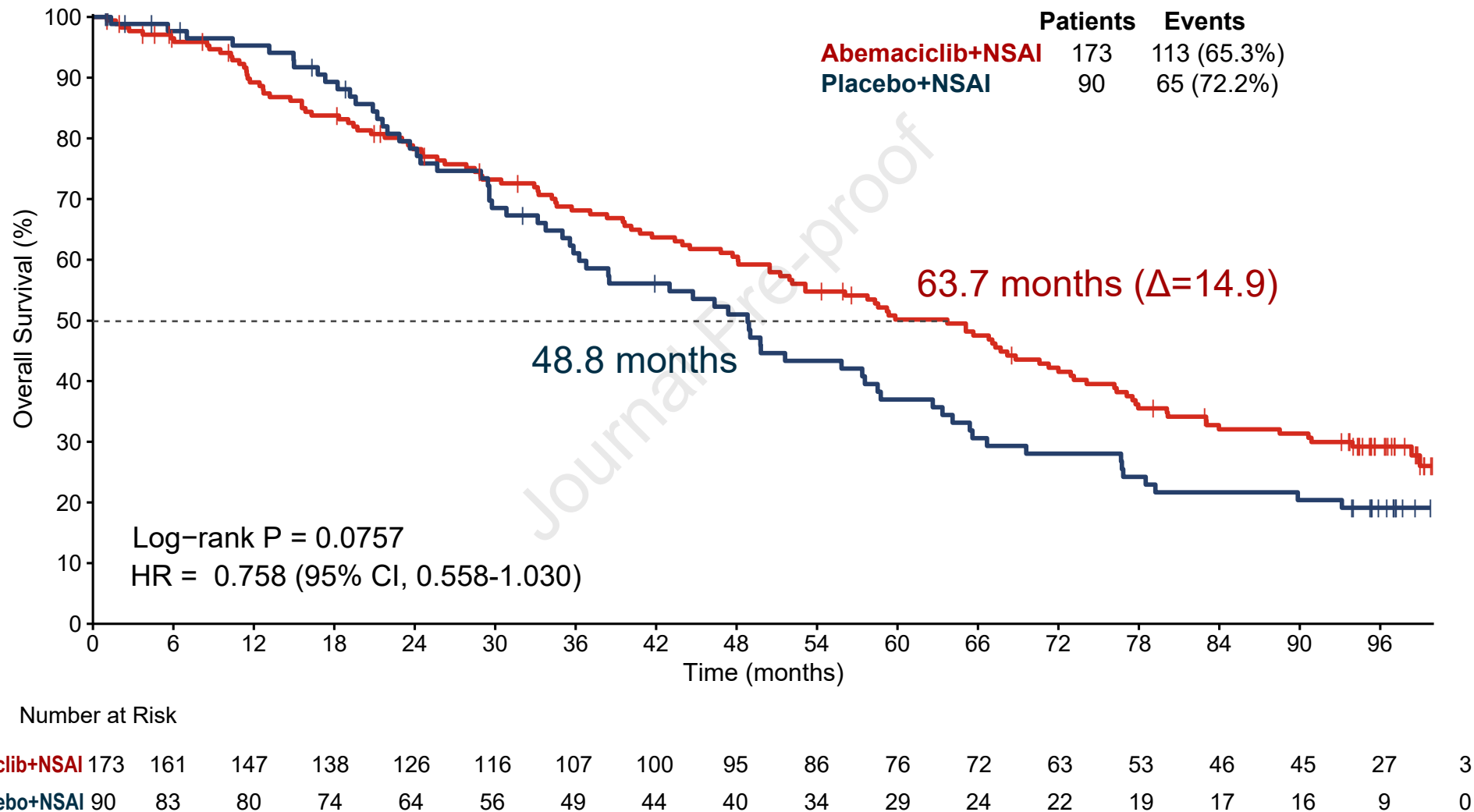
A. ITT Population

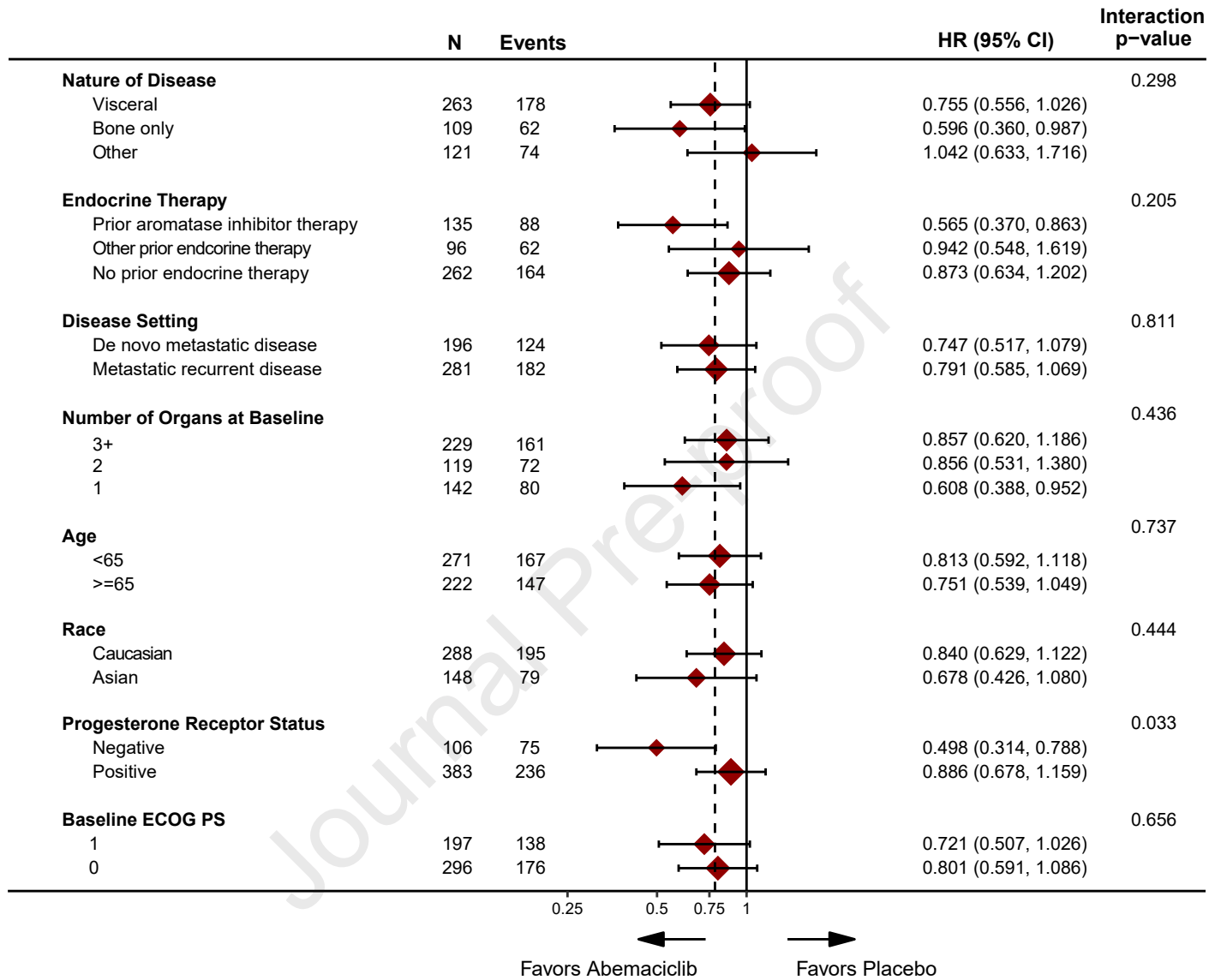


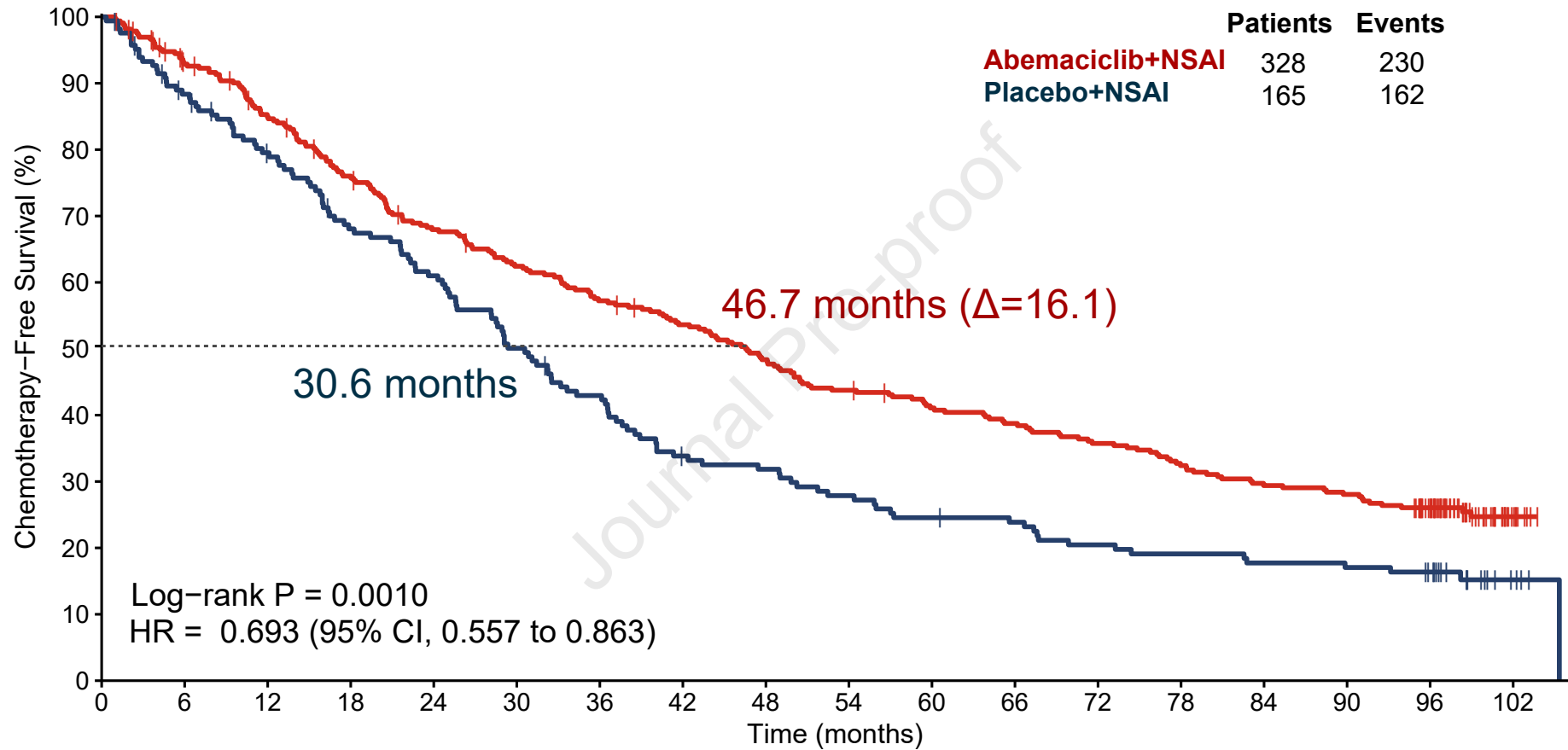
Number at Risk

Abemaciclib+NSAI	328	304	281	266	247	229	211	199	187	174	156	144	131	117	104	99	66	6
Placebo+NSAI	165	155	149	138	127	116	104	95	84	73	62	56	51	47	40	37	28	1

B. Subgroup with Visceral Disease

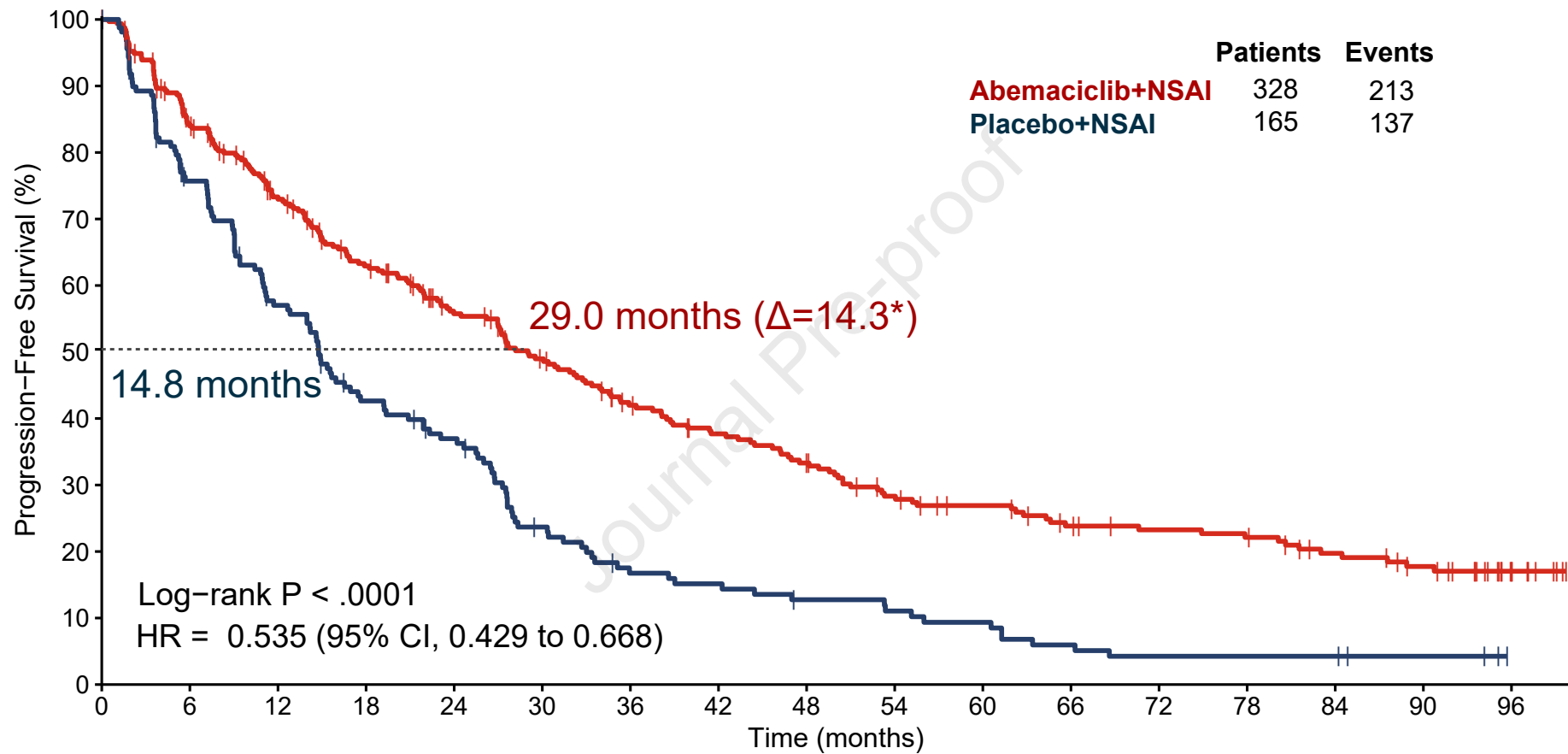






Number at Risk

Abemaciclib+NSAI	328	295	267	237	210	192	176	163	147	133	123	116	107	97	88	84	68	9
Placebo+NSAI	165	142	125	106	95	78	66	51	48	42	37	35	30	28	26	25	22	4



Number at Risk

Abemaciclib+NSAI	328	251	209	173	143	121	99	86	76	61	54	45	41	39	31	25	10
Placebo+NSAI	165	114	84	61	51	31	21	19	15	13	11	7	5	5	5	3	0