

## **Note added for release (1)**

Pilot short-term forecasts from SPI-M-O. This was considered at SAGE 29 on 28 April 2020.

It should be viewed in context: these short-term forecasts represent SPI-M-O's best predictions based on the data and evidence available at the time of writing. Therefore, some of the information in this paper may have been superseded and the author's opinion or conclusion may since have developed.

Separate forecasts are produced using different models and approaches by the modelling groups represented at SPI-M-O. These individual forecasts are then combined to form a consensus forecast which is subsequently shared with the Scientific Advisory Group for Emergencies (SAGE).

The short-term forecasts are produced by transmission models of the epidemic process. These models are fit to trends in the past data, and therefore do not predict the impact changes to social distancing measures will have on the number of COVID-19 deaths or hospitalisations - unless the impact of any changes have already started to be reflected in the data by the time the forecasts were produced.

It isn't possible to produce accurate forecasts when case numbers fall to very low levels. Furthermore, where data series are inconsistent, for example if ICU bed occupancy is decreasing much faster than general bed occupancy, the models may not always fit well to the data. If case numbers drop to very low levels in a region or the forecasts do not fit well to the data, then these forecasts are excluded from the slides circulated to SAGE.

Data limitations mean some of the forecasts aren't informed by past data. Where this is the case these forecasts need to be treated with caution and represent SPI-M-O's best assessment using the available data from other parts of the UK.

These documents are released as pre-print publications that have provided the government with rapid evidence during an emergency. These documents have not been peer-reviewed and there is no restriction on authors submitting and publishing this evidence in peer-reviewed journals.

## **Note added for release (2)**

The metrics used in these slides cover:

1. ICU bed occupancy
2. Hospital bed occupancy
3. Hospital and community deaths by date of death
4. New and newly confirmed patients/cases in hospital: Number of patients admitted with COVID-19 and inpatients diagnosed with COVID-19 in last 24 hours

Forecasts are produced for England, Scotland, Wales, Northern Ireland and NHSE regions. However, data limitations at the time meant that it was not possible to produce forecasts for all metrics for all four nations. These slides include data for:

- Scotland: ICU bed occupancy; hospital bed occupancy; hospital and community deaths
- Wales: all four metrics
- NI: ICU bed occupancy

There are also Scottish forecasts for new and newly confirmed patients/cases in hospital; and NI forecasts for hospital bed occupancy, hospital and community deaths, and new and newly confirmed patients/cases in hospital. Please note that these need to be treated with caution, as they are not informed by past data for these nations given data limitations, and are assessed using available data from other parts of the UK.

As caveated, some forecasts were excluded from the slides circulated to SAGE due to low numbers and/or poor fit to past data.

Not all of the models produce forecasts each week or for every metric.

A description of the metrics used in the short-term forecasts between SAGE 22 and 46 are listed overleaf, together with caveats for each measure and source. These are additional to the existing caveats on the individual forecast slides, and should be taken into account. Please note that the coverage and definitions of these data streams have changed over time, reflecting improved understanding of the disease and epidemic.

## Note added for release (3)

Metric	Nation	Definition and additional caveats
<b>ICU bed occupancy (discontinued after SAGE 46)</b>	<b>England</b> (SAGE 22-46)	NHS England Sitrep, field "Number of HDU/ITU beds, as at 08:00 (occupied with confirmed COVID patients)". Please note that this relates to HDU/ITU, and not mechanical ventilation (MV).  This is management information, collected on a daily basis with a tight turnaround time. No revisions are made to the dataset; where known errors have come to light trusts have made the appropriate correction in the following day's data. As of the 24 April, the forecast metric used covers all NHS trusts other than mental health and community trusts.
	<b>Scotland</b> (SAGE 27-46)	Scottish Government Sitrep, field "Total Number of Confirmed COVID-19 Inpatients in ICU at Midnight". Please note that this relates to HDU/ITU, and not mechanical ventilation (MV).  The forecast metric used included both confirmed and suspected COVID-19 patients prior to 5 May 2020. Only confirmed COVID-19 patients are included after this date.
	<b>Wales</b> (SAGE 29-46)	NHS Wales/Welsh Government Sitrep (all hospitals), field "Total number of confirmed COVID-19 patients in invasive ventilated beds".  Please note that this relates to invasive ventilated beds, both in and outside a critical care setting.
	<b>Northern Ireland</b> (SAGE 27-46)	NI Department of Health Sitrep, field "ICU Occupancy".  Please note that the forecast metric used included both confirmed and suspected COVID-19 patients prior to 24 June 2020. Only confirmed COVID-19 patients are included after this date.
<b>Hospital bed occupancy (including ICU beds) (discontinued after SAGE 46)</b>	<b>England</b> (SAGE 22-46)	NHS England Sitrep (all NHS trusts), field "Total number of beds occupied with confirmed COVID patients at 08:00 (Total)".  Please note that this is management information, collected on a daily basis with a tight turnaround time. No revisions are made to the dataset; where known errors have come to light trusts have made the appropriate correction in the following day's data. As of the 24 April, the forecast metric used covers all NHS trusts other than mental health and community trusts.
	<b>Scotland</b> (SAGE 27-46)	Scottish Government trends in daily COVID-19 data, field "COVID-19 patients in Hospital (including those in ICU) – confirmed".  The forecast metric used included both confirmed and suspected COVID-19 patients prior to 5 May 2020. Only confirmed COVID-19 patients are included after this date.
	<b>Wales</b> (SAGE 27-46)	NHS Wales/Welsh Government Sitrep (all hospitals), field "Total number of confirmed COVID-19 patients in hospital beds".  Please note that the forecast metric used included both active and recovering COVID-19 patients prior to 22 May 2020. Only active COVID-19 patients are included after this date. The forecast metric used relates to all hospitals (acute, community, mental health, field and private hospitals)
	<b>Northern Ireland</b> (SAGE 39-46)	Provided by HSCNI: "Number of inpatients on any day who were likely admitted with COVID - test positive within 28 days before admission or in first 7 days of admission"  Please note that this includes community- and indeterminate-onset cases, and excludes hospital-onset cases.

## Note added for release (4)

Metric	Nation	Definition and additional caveats
<b>Hospital deaths by date of death (discontinued after SAGE 25)</b>	<b>England</b> (SAGE 22-25)	Deaths of people in hospitals with laboratory-confirmed COVID-19 . This corresponds to the daily COVID-19 deaths in England reported as part of the daily 10 Downing Street press conferences before 29 April 2020 (SAGE 29 and earlier). It is important to note that these figures are subject to reporting practices and working patterns.
	<b>Scotland</b>	N/A
	<b>Wales</b>	N/A
	<b>Northern Ireland</b>	N/A
<b>Hospital and community deaths by date of death</b>	<b>England</b> (SAGE 23-51)	PHE line list of deaths, by date of death Deaths of people with laboratory-confirmed COVID-19. This does not include deaths of people where COVID-19 is suspected, but not laboratory confirmed - but is a more timely measure.  Please note that this data was prior to the change in definition on 12 August, and this measure relates to deaths of people with laboratory-confirmed COVID-19 with no time restriction imposed. Recent data points at the time of forecast will be more uncertain due to reporting delays.  More information on this change can be found in the PHE data series on deaths in people with COVID-19: technical summary: <a href="https://www.gov.uk/government/publications/phe-data-series-on-deaths-in-people-with-covid-19-technical-summary">https://www.gov.uk/government/publications/phe-data-series-on-deaths-in-people-with-covid-19-technical-summary</a>
	<b>Scotland</b> (SAGE 27-51)	Public Health Scotland deaths line list Daily number of COVID-19 deaths, defined as individuals who die within 28 days of their first laboratory confirmed report of COVID-19 infection, and are registered with National Records of Scotland
	<b>Wales</b> (SAGE 27-51)	Public Health Wales deaths line list, field "Suspected COVID-19 deaths in lab confirmed cases" This relates to deaths of hospitalised patients in Welsh Hospitals or care home residents where COVID-19 has been confirmed with a positive laboratory test and the clinician suspects this was a causative factor in the death
	<b>Northern Ireland</b> (SAGE 44-51)	NI Department of Health Sitrep, field "deaths by date of death (historic figures updated retrospectively as at the date the overall spreadsheet is updated)" Deaths reported to the PHA where the deceased has had a positive test for COVID-19 and died within 28 days, whether or not COVID-19 was the cause of death

## Note added for release (5)









Metric	Nation	Definition and additional caveats
<b>New and newly confirmed cases in hospital (discontinued after SAGE 41)</b>	<b>England</b> (SAGE 22-41)	NHS England Sitrep, sum of fields "Number of inpatients diagnosed with COVID-19 in last 24 hours (Total)" and "Number of patients admitted with COVID-19 in last 24 hours (Total)".  Please note that this is management information, collected on a daily basis with a tight turnaround time. No revisions are made to the dataset; where known errors have come to light trusts have made the appropriate correction in the following day's data. As of the 24 April, the forecast metric used covers all NHS trusts other than mental health and community trusts.
	<b>Scotland</b> (SAGE 33-41)	"Scotland Tested Positive in Hospitals" file. New and newly confirmed COVID-19 patients in hospital, sum of fields "N.Positive.In.Hospital" and "N.Positive.On.Admission".
	<b>Wales</b> (SAGE 29-41)	"SPI-M_PHW_ICNet_HospitalData" file, "All admissions" sheet.
	<b>Northern Ireland</b> (SAGE 39-41)	Provided by HSCNI: patients admitted with COVID (positive test), and patients testing positive with COVID-19 in hospital

# SPI-M Short-term forecasts

As of 27 April 2020

**Pilot**

## Models:

 PHE/Cambridge Regional/age	 Imperial Microsimulation	 LSHTM Transmission
 LSHTM Branching process	 Manchester/Oxford	 Imperial Stochastic Compartmental
 PHE/Cambridge Regional	 Warwick	

- *Imperial Microsimulation*: model fitted to multiple data streams
  - *Imperial Stochastic Compartmental*: micro simulation model fitted to multiple data streams
  - *LSHTM Branching Process*: model fitted to new cases in hospital; combined with a time series model to forecast trends in transmission
  - *LSHTM Transmission*: age-specific regional stochastic SEIR model fitted to multiple data streams
  - *Manchester/Oxford*: deterministic SEIR model fitted to new cases in hospital
  - *PHE/Cambridge*: deterministic transmission model combined with a disease reporting model, fitted to deaths by date; two variants: one regional, one age-stratified
  - *Warwick*: age-structured SEIR model fitted to multiple data streams
- None of the models separate out transmission routes in the community, hospitals or other settings. Presented numbers are of overall cases.

## Forecasts: 2 weeks ahead

- *ICU beds occupied*: number of patients with COVID-19 in HDU/ITU at any time
- *Total beds occupied*: number of patients with COVID-19 in any bed (including HDU/ITU) at any time
- *Hospital and community deaths (by date of death)*: number of deaths due to COVID-19 as per PHE, PHS and PHW death line lists.
- *New and newly confirmed patients in hospital*: new admissions of patients previously tested positive for COVID-19 and new positive test results of inpatients

### Note added for release:

The description for the Manch/Oxf model should read "deterministic SEIR model fitted via MLE to daily hospital admissions, hospital prevalence, ICU prevalence, and daily hospital deaths"

## General notes:

Forecasts are produced by individual models and combined. Models are combined by fitting a normal distribution to each individual predictive distribution and aggregating them in a normal mixture distribution with equal weights.

Only 2 weeks of data are shown, but data going back longer has been used to inform the models.

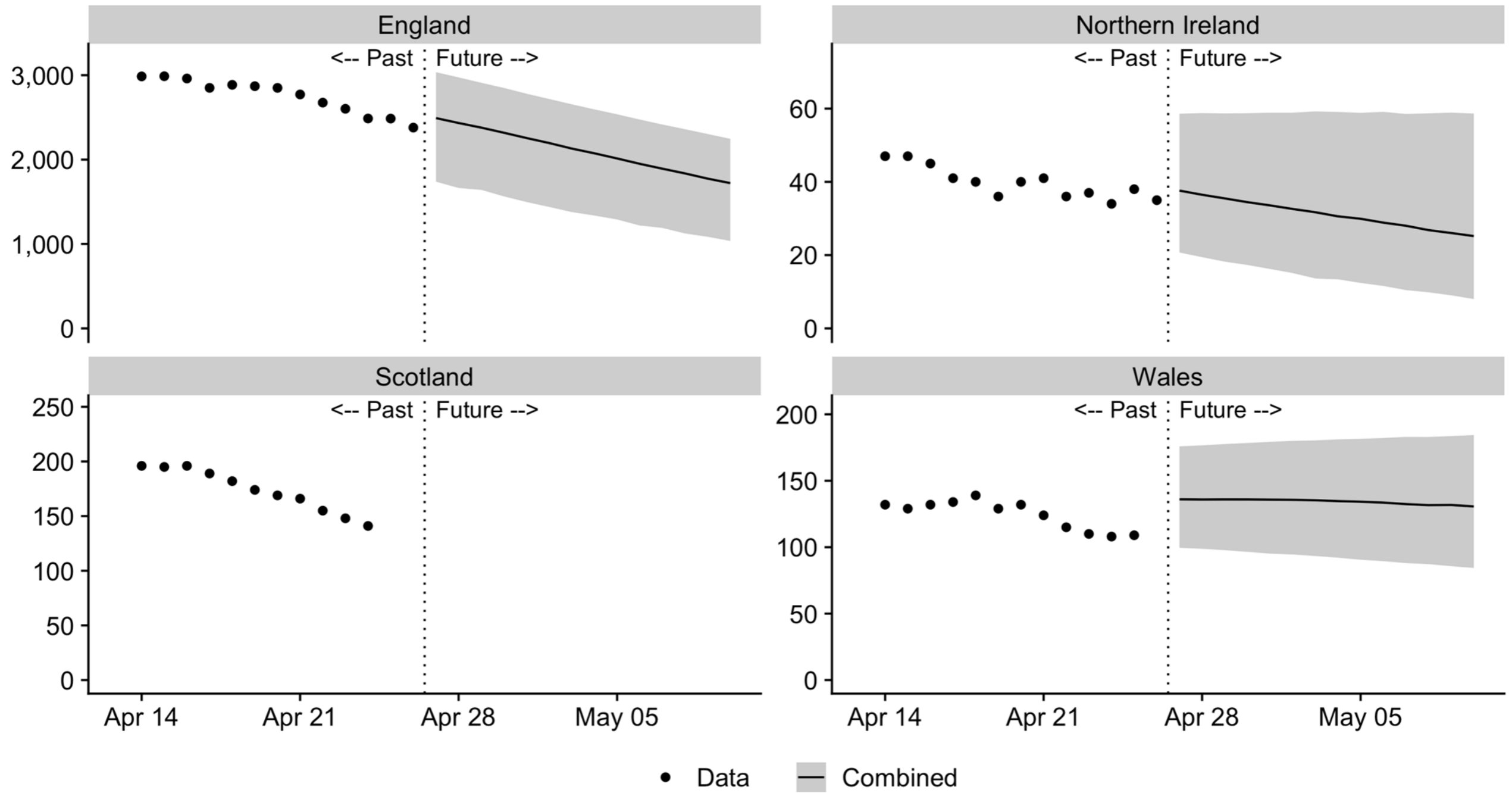
Several additional modelling groups have started to produce forecasts for Scotland, Wales and Northern Ireland. As a result it has been possible to extend the coverage of the forecasts beyond England for several metrics.

However, data limitations mean it has not been possible to produce forecasts for every metric for all four nations. We are continuing to work with colleagues in the devolved administrations to ensure SPI-M modellers get access to this data on a comparable basis to England and these gaps can be filled.



# ICU beds occupied

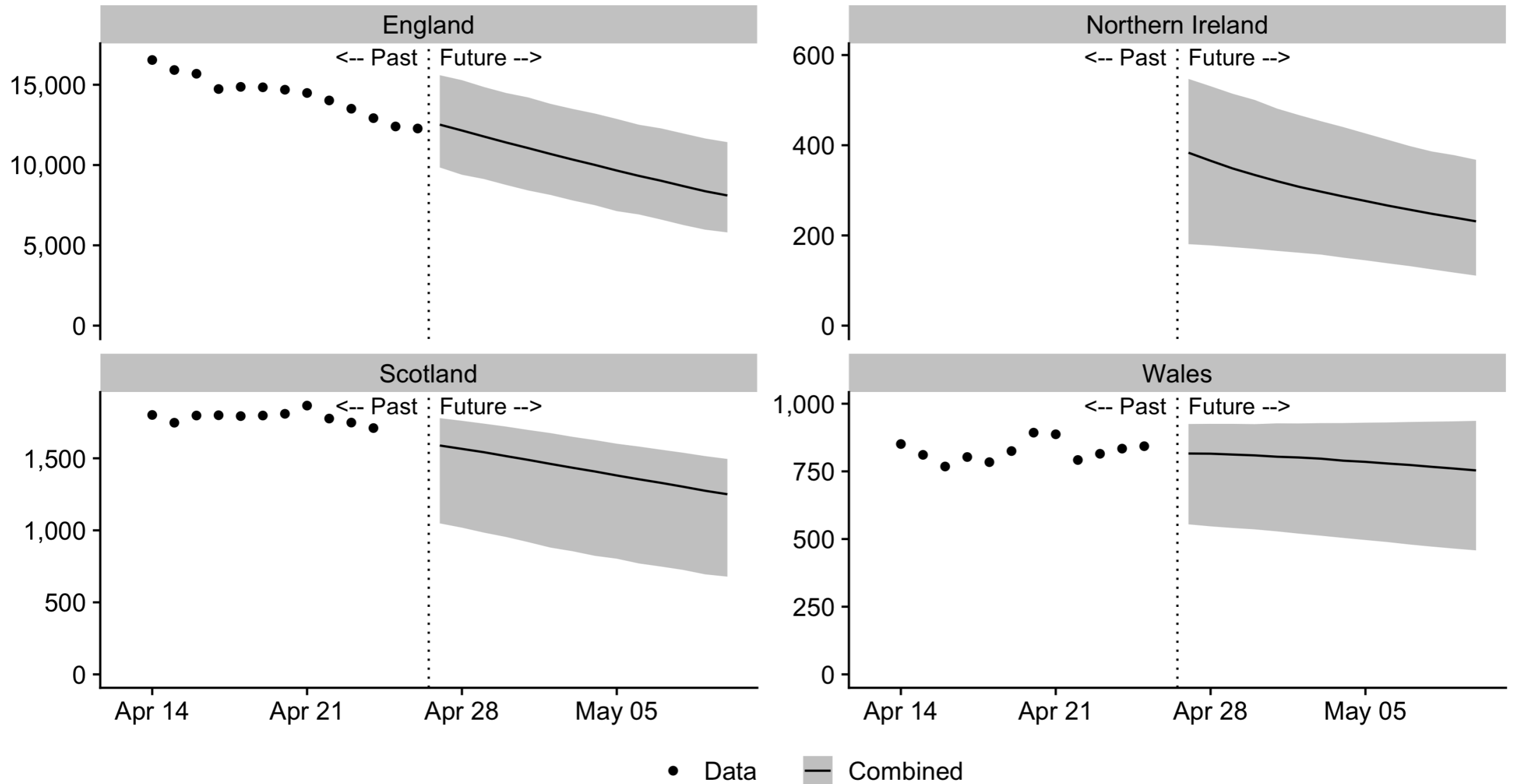
Combined forecasts



**Note:** Total number of ICU beds occupied on any given day. This depends on the distribution of lengths of stay, which is estimated separately for the different models from different data sources. The forecast for Scotland has been excluded from this iteration. This will be available again from Thursday. Shaded area: 90% confidence.

# Total beds occupied

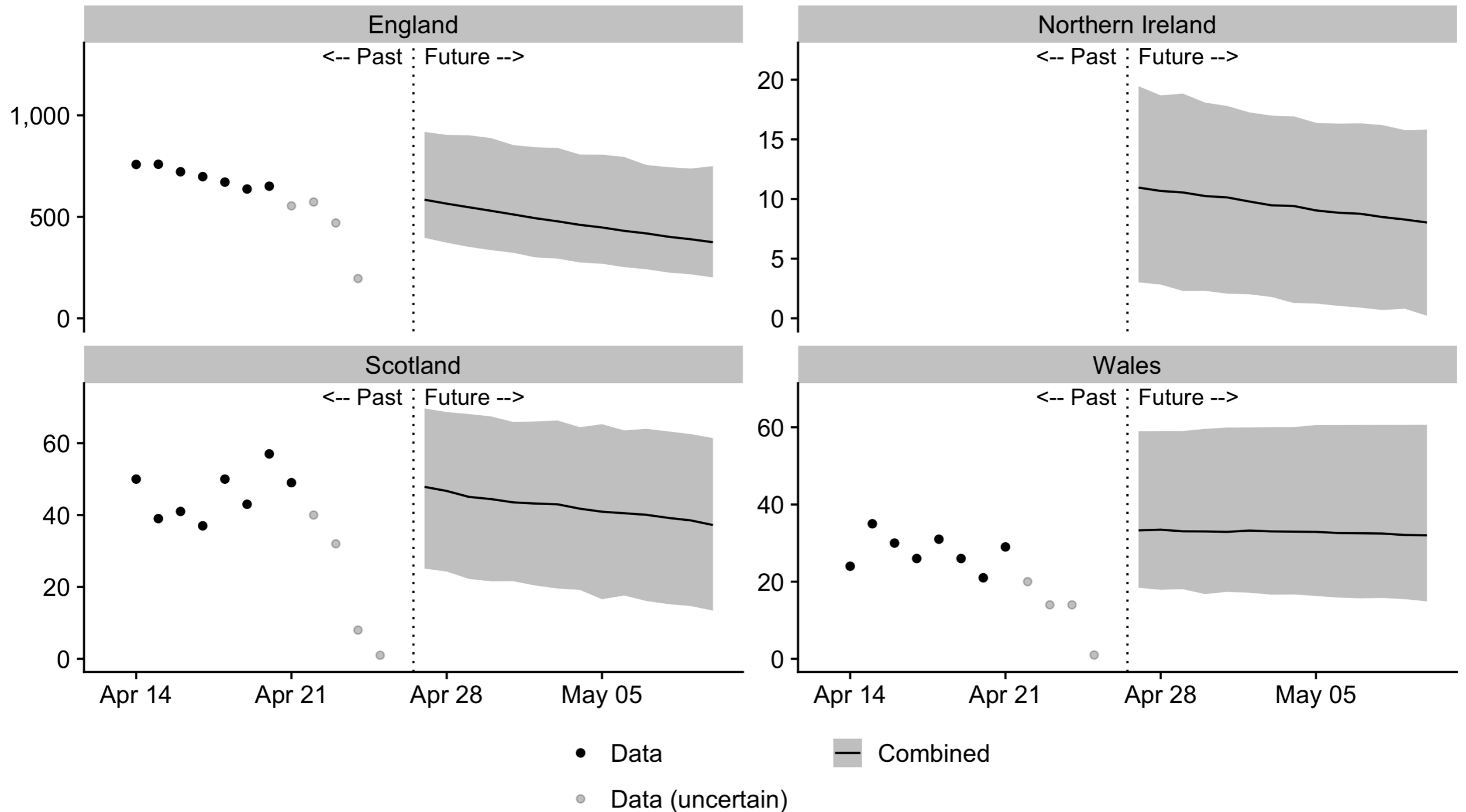
Combined forecasts



**Note:** Total number of beds (including ICU) occupied on any given day. This depends on the distribution of lengths of stay, which is estimated separately for the different models from different data sources. Scotland data includes suspected cases. We are working to add data for Northern Ireland. Shaded area: 90% confidence.

# Hospital and community deaths (by date of death)

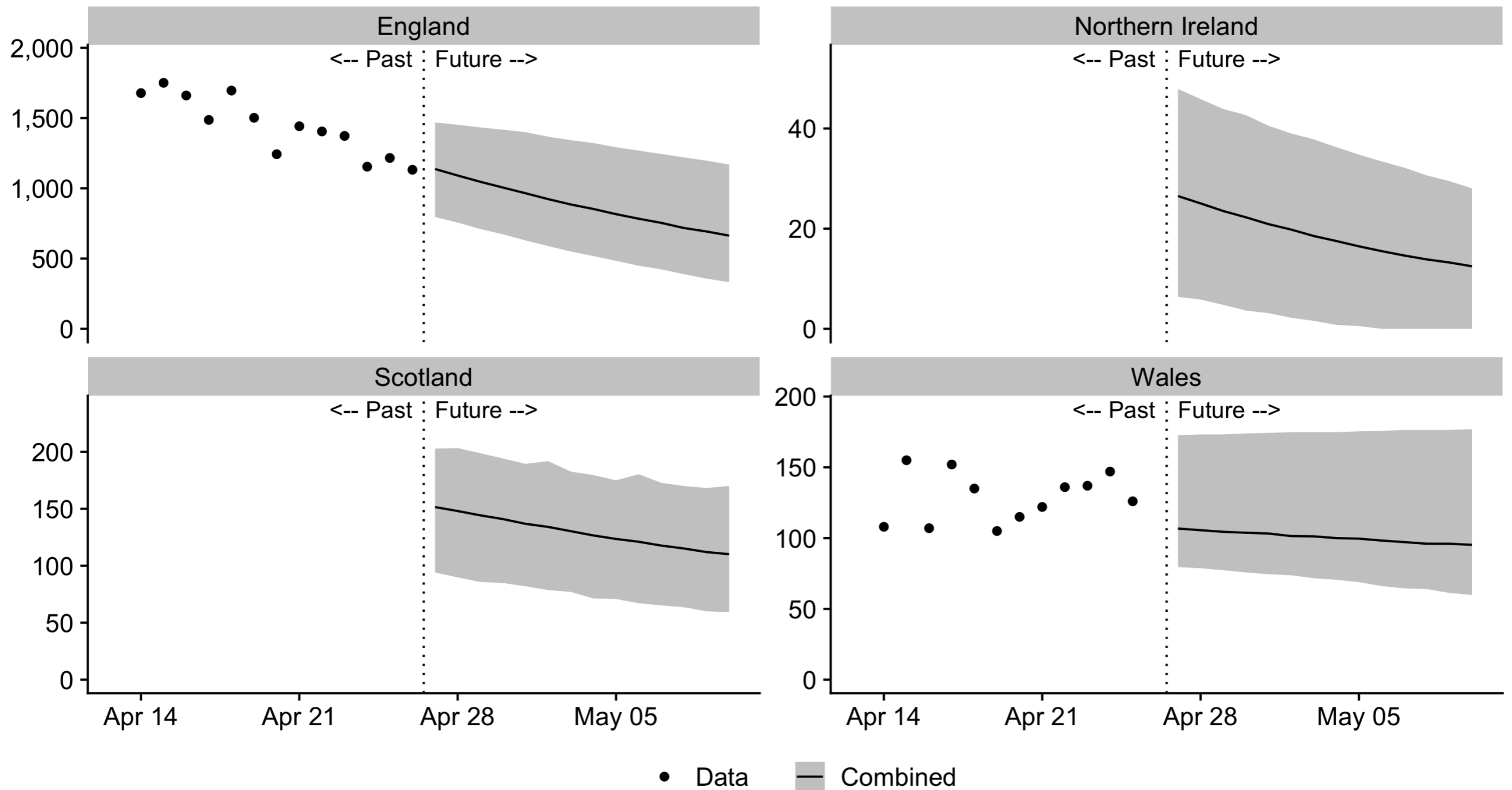
Combined forecasts



**Note:** The four most recent data points are coloured in grey to reflect uncertainty due to reporting delays. This is based on the PHE, PHS and PHW line lists of deaths and may not represent all deaths due to COVID-19. We are working with the ONS to produce a more complete data set of deaths for the whole of the UK. Shaded area: 90% confidence

# New and newly confirmed patients in hospital

Combined forecasts



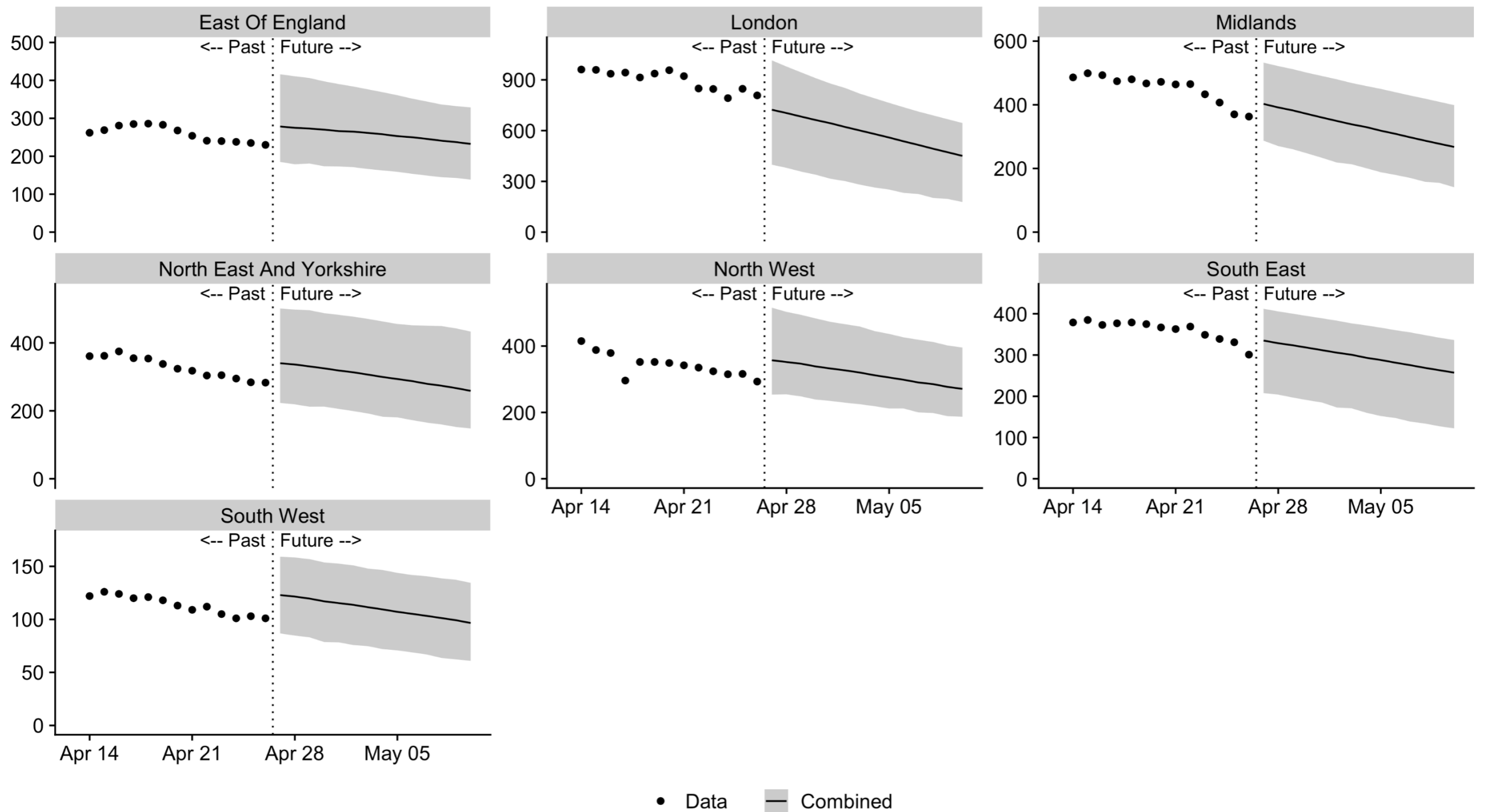
**Note:** Includes new admissions that tested positive, new admissions that were tested positive prior to admission, and existing patients that tested positive. We are working to produce data sets including all UK nations. Shaded area: 90% confidence.

# Annex: Regional plots

England only

# ICU beds occupied

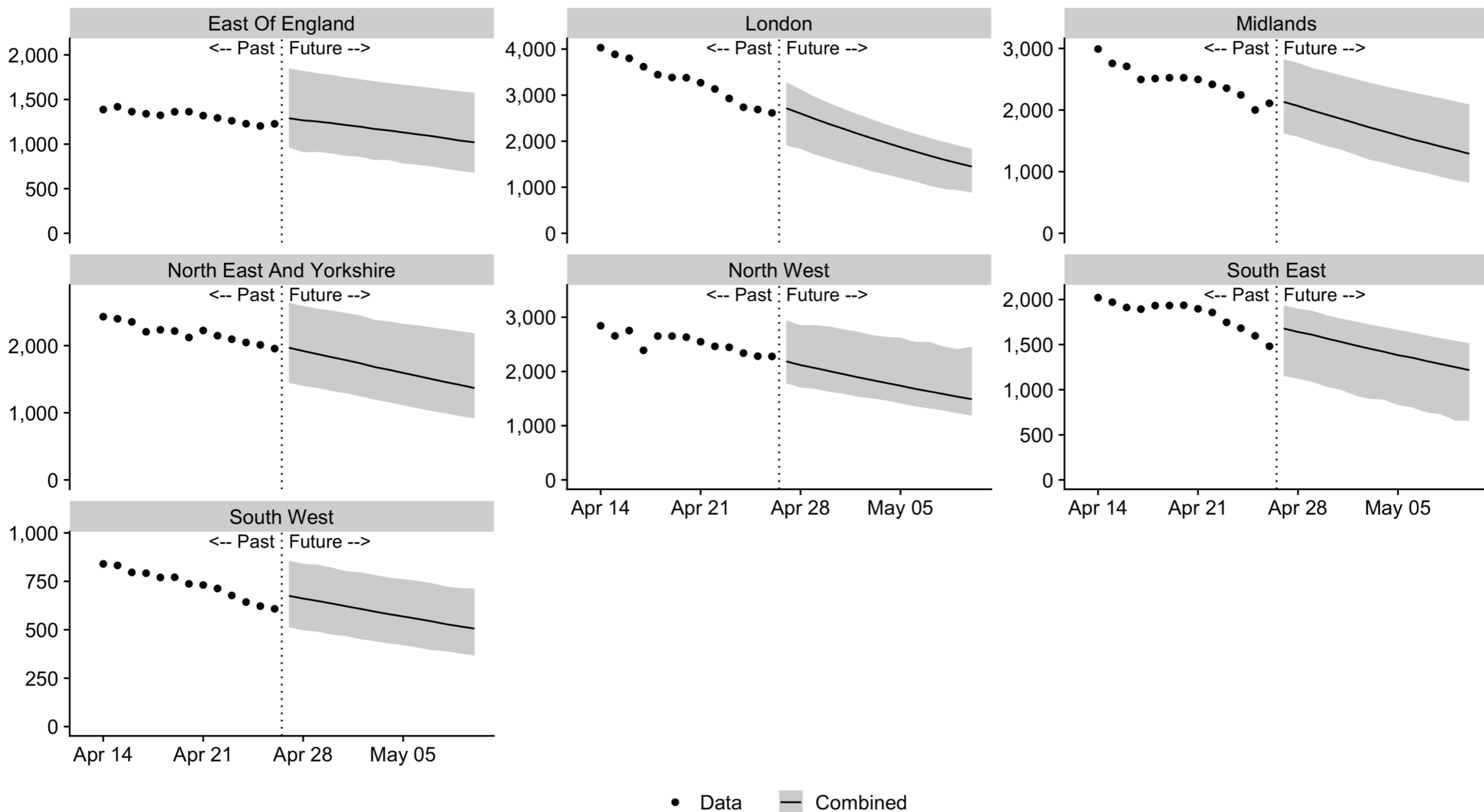
Combined forecasts



**Note:** Total number of ICU beds occupied on any given day. This depends on the distribution of lengths of stay, which is estimated separately for the different models from different data sources. Shaded area: 90% confidence.

# Total beds occupied

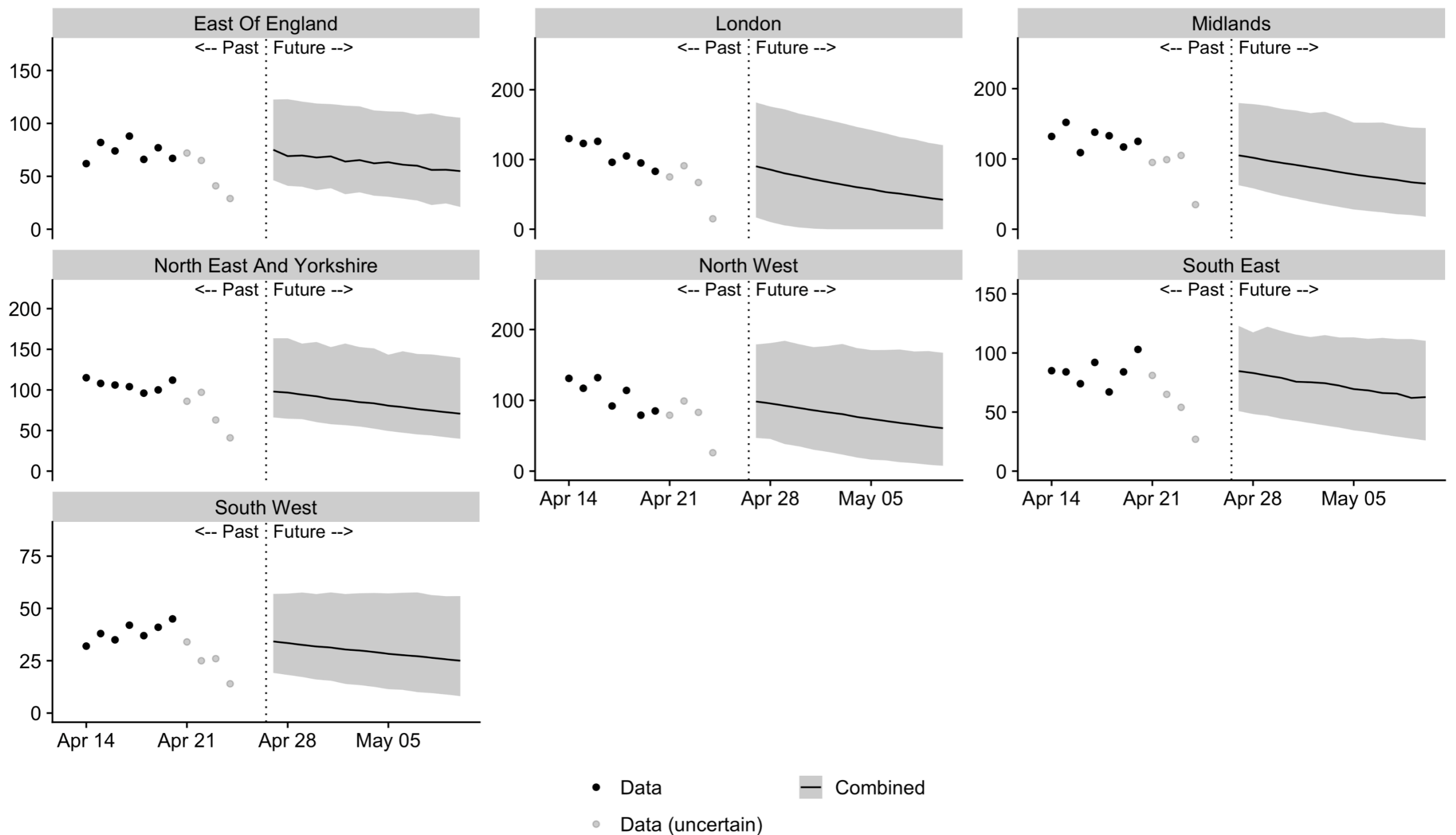
Combined forecasts



**Note:** Total number of beds (including ICU) occupied on any given day. This depends on the distribution of lengths of stay, which is estimated separately for the different models from different data sources. Shaded area: 90% confidence.

# Hospital and community deaths (by date of death)

Combined forecasts

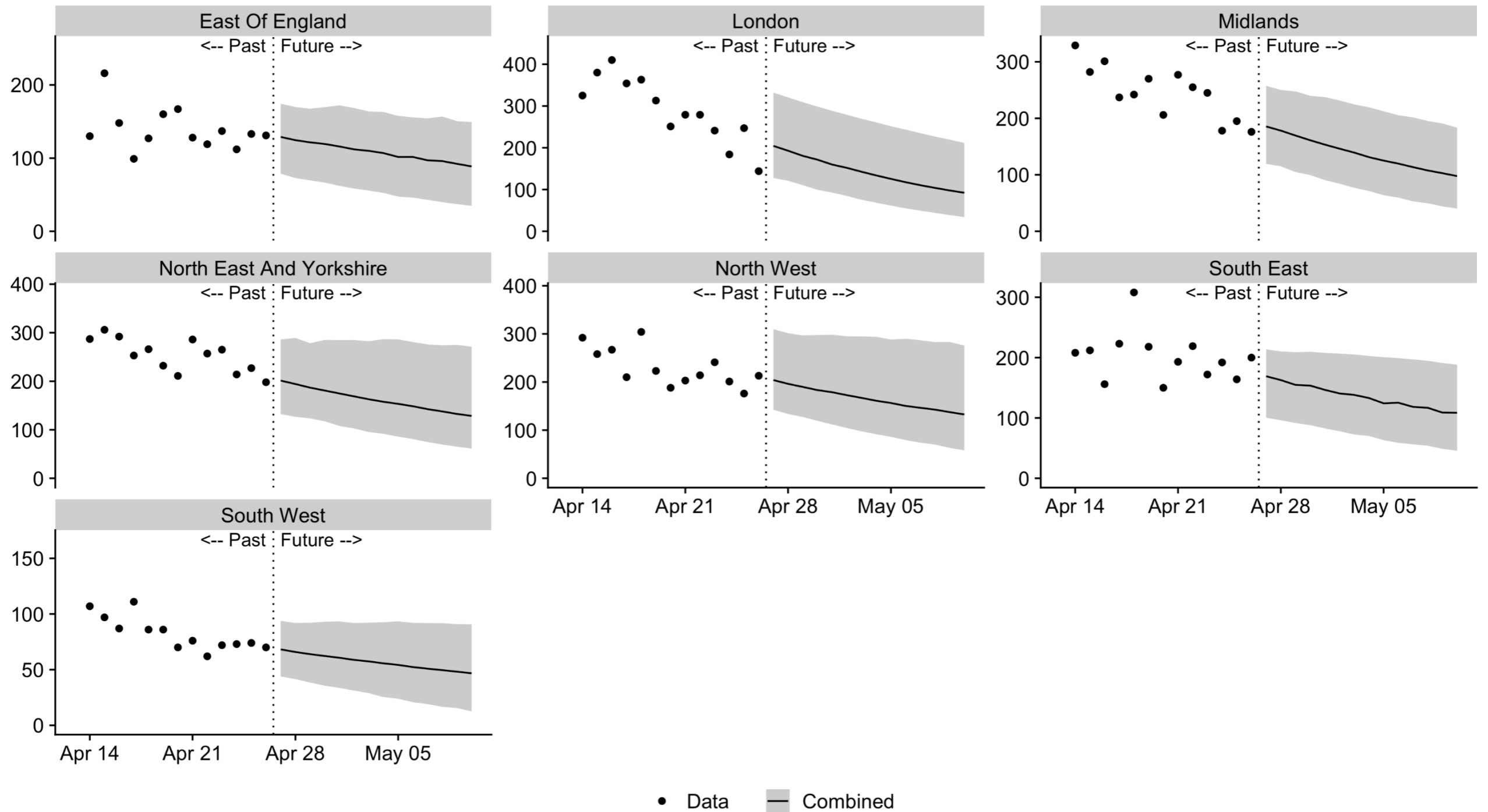


**Note:** The four most recent data points are coloured in grey to reflect uncertainty due to reporting delays. This is based on the PHE line list of deaths and may not represent all deaths due to COVID-19. We are working with the ONS to produce a more complete data set of deaths. Shaded area: 90% confidence.



# New and newly confirmed patients in hospital

Combined forecasts



**Note:** Includes new admissions that tested positive, new admissions that were tested positive prior to admission, and existing patients that tested positive. Shaded area: 90% confidence.