



2023년 국내 카바페넴내성장내세균목 감염증의 신고 현황

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초 록

카바페넴내성장내세균목(carbapenem-resistant *Enterobacterales*, CRE) 감염증은 전 세계적으로 증가하는 추세이며, 주요 공중보건 위협 문제로 대두되고 있다. 미국 질병통제예방센터는 코로나바이러스감염증-19(코로나19) 팬데믹으로 의료기관에서 코로나19 감염관리를 우선 조치하는 등의 이유로 일상적인 감염 예방관리가 어려워져 CRE 감염증 증가가 심화되었음을 보고하였고, 세계보건기구(World Health Organization, WHO)는 「WHO bacterial priority pathogens list, 2024」를 통해 2019년 전 세계적으로 495만명이 항생제 내성균과 관련하여 사망한 것으로 추정하였다. 국내 CRE 감염증은 2017년 6월부터 전수감시체제로 운영되고 있으며, CRE 감염증 발생 신고 건은 매년 약 20-30%씩 큰 폭으로 증가하고 있는 상황이다. 2023년 CRE 감염증 신고 자료 분석 결과, 총 38,405건 중 남성의 비율이 55.4%였고, 연령별 발생 분포는 70세 이상의 연령에서 65.2%였으며, 의료기관 중별로는 종합병원의 신고 비율이 43.3%로 가장 높았다. 특히, 요양병원의 CRE 감염증 신고 건과 비율이 매년 증가하여, 2019년 1,077건(7.0%)에서 2023년에는 5,815건(15.1%)으로 확인되었다. 2023년 CRE 감염증 신고 자료의 병원체 특성을 살펴보면, 주요 분리균은 *Klebsiella pneumoniae*로 전체의 72.4%를 차지하였고, *Escherichia coli*는 14.1%를 차지하였다. 2023년 CRE 감염증 중 카바페넴분해효소를 생성하는 CRE(carbapenemase-producing *Enterobacterales*, CP-CRE) 감염증은 전체 신고 건의 73.7%로, CRE 감염증 신고건 중 CP-CRE 감염증의 비율도 매년 증가하고 있다. 이에 본 보고서는 2019년부터 2023년까지 최근 5년간 질병관리청의 질병보건통합시스템을 통해 CRE 감염증으로 신고·보고된 사례를 기반으로 국내 CRE 감염증의 발생 현황과 역학적 특성을 분석함으로써, 효과적인 감염 예방 및 관리 전략을 수립하는 데 중요한 자료를 제공하고자 하였다.

주요 검색어: 카바페넴내성장내세균목; 카바페넴분해효소생성장내세균목; 항생제 내성

서 론

카바페넴내성장내세균목(carbapenem-resistant *Enterobacterales*, CRE) 감염증은 최근 전세계적으로 널리 확산되어 공중보건에 큰 위협이 되고 있으며[1-3], 특히 코로나바이러스감염

증-19(코로나19) 팬데믹으로 인해 의료자원의 부족, 감염관리 소홀, 항생제 사용 증가 등의 요인으로 CRE 감염증 증가가 심화되었다[4].

CRE 감염증은 항생제 내성균 중 카바페넴 계열의 항생제에 내성인 장내세균목에 의한 감염질환으로 주로 환자나 그

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핵심요약

① 이전에 알려진 내용은?

국내 카바페넴내성장내세균목(carbapenem-resistant *Enterobacterales*, CRE) 감염증 신고 건은 2019년 이후 매년 20-30%씩 증가하고 있다. 최근 CRE 감염증 신고 건 중 카바페넴분해효소를 생성하는 CRE (carbapenemase-producing *Enterobacterales*, CP-CRE)의 양성 비율이 70% 이상 차지하며, 점차 비중이 증가하는 추세이다.

② 새로이 알게 된 내용은?

2023년 CRE 감염증 신고 38,405건 중 종합병원의 발생 신고 비율이 43.3%로 가장 높았으며, 요양병원 발생 비율은 2019년 7.0%에서 2023년 15.1%로 증가하였다. CP-CRE 감염증은 전체 CRE 감염증 환자 중 73.7% (28,318건)이며, 작년 대비 신고 의료기관 수도 27.4% 증가하여 1,117개소였다.

③ 시사점은?

국내 CRE 감염증의 발생 현황과 역학적 특성을 이해하고, 효과적인 감염 예방 및 관리 전략을 수립하는 데 중요한 자료를 제공하였다. 질병관리청, 지자체, 의료기관은 CRE 감염증 확산 억제를 위해 지속적인 감시와 더불어 적극적인 감염관리가 필요할 것이다.

주변 환경과 직접 또는 간접적인 접촉 등으로 전파되며, 장기 입원환자, 면역억제제 투여자, 이전 CRE 감염증 과거력이 있는 경우 등에서 발생 위험성이 높다[5]. 특히, CRE 중 카바페넴분해효소를 생성하는 CRE (carbapenemase-producing *Enterobacterales*, CP-CRE)는 플라스미드 또는 기타 메커니즘을 통해 내성 유전자를 다른 세균으로 전달하여 빠른 전파를 초래함으로써 집단감염의 문제가 되고 있다[6]. 최근 국내 CRE 감염증 신고 자료 현황을 보면, CRE 중 CP-CRE 비율이 매년 지속적으로 증가하고 있는 추세로 의료기관 내 집단발생에 대한 적극적 관리가 필요하다[7,8].

이에 본 보고서에서는 CRE 감염증의 변화되는 양상을 파악하고자 최근 5년간(2019-2023년) CRE 감염증 발생 현황과 역학적 특성 등을 비교·분석하였다.

방 법

2019년부터 2023년까지 질병관리청 질병보건통합관리 시스템을 통해 보고된 (1) CRE 감염증 발생신고서, (2) CRE 감염증 사례조사서, (3) CP-CRE 감염증 신고서를 기반으로 인구학적 특성(성별, 연령) 및 역학적 특성(지역별, 의료기관 종별, 감염병환자 분류별, 분리군별, 카바페넴분해효소별 등)을 분석하였다. 분석 자료는 의료기관 감염병 발생 신고일을 기준으로 산출하였으며, 2019년부터 2022년까지 CRE 감염증 분석 결과는 감염병 감시 연보 및 CRE 감염증 분석 보고 자료[7,8]를 활용하였다.

결 과

1. Carbapenem-resistant *Enterobacterales* 감염증 신고 현황

제2급감염병인 CRE 감염증은 현재 전수감시체계로 운영 중이며, 전수감시를 시작한 2017년 6월 이후 신고 건은 매년 약 20-30%씩 증가하여, 2023년에는 1,467개 의료기관에서 총 38,405건이 신고되었다(표 1).

2023년 CRE 감염증 신고 건의 인구학적 특성을 확인한 결과, 남성이 55.4% (21,293건)이며, 70세 이상이 65.2% (25,057건), 60-69세가 18.5% (7,112건), 50-59세가 8.9% (3,416건) 순이었다. 전체 신고 건 중 70세 이상 연령은 2019년 58.8% (9,031건)에서 2023년 65.2% (25,057건)로 매년 발생 비율이 증가하고 있다. 의료기관 종별 신고 현황을 보면 종합병원 43.3% (16,648건), 상급종합병원 35.0% (13,443건), 요양병원 15.1% (5,815건), 병원 5.5% (2,105건) 순이었다. 특히, 요양병원 신고 건은 2019년 7.0% (1,077건), 2020년 8.2% (1,485건), 2021년 10.2% (2,383건), 2022년 12.3% (3,760건), 2023년 15.1% (5,815건)로 신고 건과 비율이 증가하였다.

표 1. 2019-2023년 CRE·CP-CRE 감염증 연도별 신고건 및 의료기관 수

구분		2019	2020	2021	2022	2023
CRE 감염증	발생 건	15,369	18,113	23,311	30,548	38,405
	의료기관 수(개소)	831	938	1,067	1,257	1,467
CP-CRE 감염증	발생 건	8,887	11,218	14,769	21,695	28,318
	의료기관 수(개소)*	622	670	717	877	1,117
CP-CRE/CRE 발생 비율(%)		57.8	61.9	63.4	71.0	73.7

CRE=carbapenem-resistant *Enterobacterales*; CP-CRE=carbapenemase-producing *Enterobacterales*. *해당 연도에 CP-CRE가 1건이라도 발생한 의료기관 수.

표 2. 2019-2023년 carbapenem-resistant *Enterobacterales* 감염증 신고 현황

분류	2019	2020	2021	2022	2023
계	15,369	18,113	23,311	30,548	38,405
성별					
남성	8,727 (56.8)	10,210 (56.4)	13,362 (57.3)	17,036 (55.8)	21,293 (55.4)
여성	6,642 (43.2)	7,903 (43.6)	9,949 (42.7)	13,512 (44.2)	17,112 (44.6)
연령별					
0-19세	333 (2.2)	311 (1.7)	336 (1.4)	341 (1.1)	456 (1.2)
20-39세	513 (3.3)	502 (2.8)	667 (2.9)	784 (2.6)	895 (2.3)
40-49세	760 (4.9)	774 (4.3)	1,042 (4.5)	1,246 (4.1)	1,469 (3.8)
50-59세	1,789 (11.6)	2,035 (11.2)	2,372 (10.2)	2,914 (9.5)	3,416 (8.9)
60-69세	2,943 (19.1)	3,405 (18.8)	4,587 (19.7)	5,864 (19.2)	7,112 (18.5)
70세 이상	9,031 (58.8)	11,086 (61.2)	14,307 (61.4)	19,399 (63.5)	25,057 (65.2)
의료기관 종별					
상급종합병원	6,266 (40.8)	7,099 (39.2)	9,442 (40.5)	11,737 (38.4)	13,443 (35.0)
종합병원	6,803 (44.3)	8,013 (44.2)	9,786 (42.0)	13,298 (43.5)	16,648 (43.3)
병원	1,093 (7.1)	1,380 (7.6)	1,512 (6.5)	1,515 (5.0)	2,105 (5.5)
요양병원	1,077 (7.0)	1,485 (8.2)	2,383 (10.2)	3,760 (12.3)	5,815 (15.1)
기타*	130 (0.8)	136 (0.8)	188 (0.8)	238 (0.8)	394 (1.0)
감염병환자 등 분류					
환자	774 (5.0)	972 (5.4)	1,312 (5.6)	1,897 (6.2)	2,067 (5.4)
병원체보유자	14,595 (95.0)	17,141 (94.6)	21,999 (94.4)	28,651 (93.8)	36,338 (94.6)

단위: 건(%). *기타=의원급 의료기관, 치과 및 한방병원 등.

또한, CRE 감염증 분류 기준에 따른 2023년 신고 자료 분석 결과, 혈액에서 CRE가 검출된 '환자'는 5.4% (2,067건)이며, 혈액 이외 임상검체에서 CRE가 검출된 '병원체보유자'는 94.6% (36,338건)이다(표 2).

2023년 CRE 감염증 신고 38,405건 중 개별 사례조사서 등록 건은 총 36,680건(95.5%)이며, 분리균은 *Klebsiella pneumoniae*가 72.4% (26,553건), *Escherichia coli*가 14.1%

(5,155건), *Enterobacter spp.*가 6.0% (2,215건), *Citrobacter freundii*가 1.9% (681건), *Citrobacter koseri*가 1.3% (466건) 순이었다. 이는 2019-2023년까지 최근 5년간 상위 5개 분포하고 있는 5가지 분리균으로 전체 중 차지하는 비율 순위가 거의 변동은 없었다. 특히, 가장 많은 분포를 차지하고 있는 *K. pneumoniae*는 2019년 60.4%, 2020년 62.6%, 2021년 68.6% 2022년 70.9%, 2023년 72.4%로 2019년 이후 매

년 비율이 증가하는 추세임을 확인하였다(보충 표 1; available online).

2. Carbapenemase-producing *Enterobacterales* 감염증 신고 현황

2023년 CRE 감염증 신고 건 38,405건 중 CP-CRE 감염증의 비율은 73.7%로 의료기관 1,117개소에서 총 28,318건이 확인되었다. 2019년 57.8% (8,887건), 2020년 61.9% (11,218건), 2021년 63.4% (14,769건), 2022년 71.0%

(21,695건), 2023년 73.7% (28,318건)로 CP-CRE 감염증 비율은 매년 증가하였다(표 1).

카바페넴분해효소 분포는 *Klebsiella pneumoniae* carbapenemase (KPC) 77.4% (21,907건), New Delhi metallo-β-lactamase (NDM) 15.9% (4,487건), oxacillinase (OXA) 6.2% (1,766건) 순이었다. 이는 2019-2023년까지 상위 3분포하는 3가지 유전자형으로, 해당 유전자형은 전체 중 차지하는 비율 순위에 변동이 없었다. 특히, 2019년 이후 전체 카바페넴분해효소 중 KPC의 비율은 지속적으로 증가하였고,

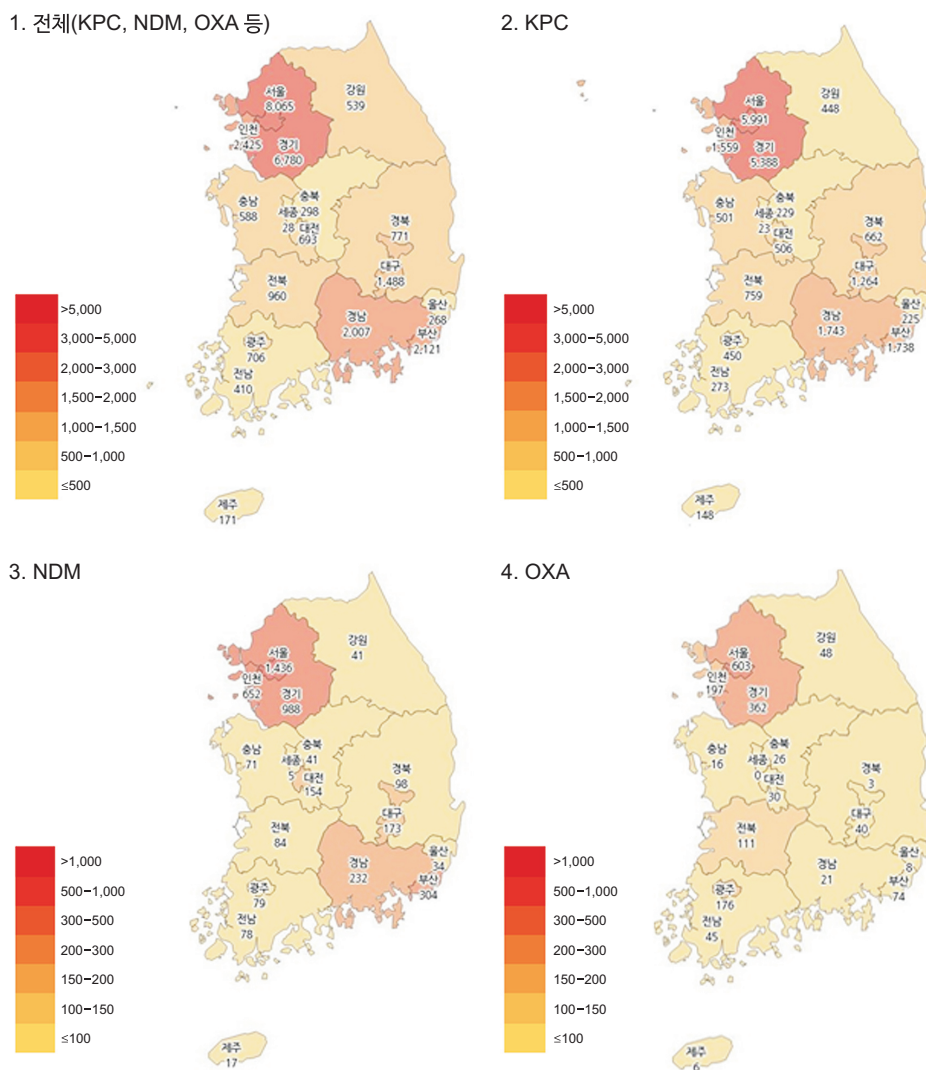


그림 1. 2023년 지역별 CP-CRE 감염증 카바페넴분해효소 분포 현황

CP-CRE=carbapenemase-producing *Enterobacterales*; KPC=*Klebsiella pneumoniae* carbapenemase; NDM=New Delhi metallo-β-lactamase; OXA=oxacillinase; 기타=Verona integron-encoded metallo-β-lactamase, Imipenemase, Guiana extended spectrum β-lactamase.

NDM의 비율은 감소하였다(보충 표 2; available online).

카바페넴분해효소의 지역별 분포 분석 결과, KPC 분포는 서울 27.3% (5,991건), 경기 24.6% (5,388건), 경남 8.0% (1,743건) 순이었으며, NDM은 서울 32.0% (1,436건), 경기 22.0% (988건), 인천 14.5% (652건)였으며, OXA는 서울 34.1% (603건), 경기 20.5% (362건), 인천 11.2% (197건)로 확인하였다(그림 1, 표 3).

논 의

CRE 감염증은 국내외에서 지속적으로 증가하고 있는 상황으로, 미국 질병통제예방센터는 「COVID-19: U.S. impact on antimicrobial resistance, special report 2022」를 통해 의료기관 내 CRE 감염증 발생이 2019년도 대비 코로나19 팬데믹인 2020년에 35.0% 증가하였으며 2021년에 정점을 찍고 2022년에도 팬데믹 이전 수준 이상을 유지하였다고 발표하였

다[4].

국내 CRE 감염증은 전수감시 시작(2017년 6월) 이후, 신고 건 및 신고 의료기관 수가 지속적으로 증가하는 추세이다. 특히, 요양병원 신고 건(의료기관 수)은 2020년 1,458건(322기관)에서 2023년 5,815건(566기관)으로, 신고 건은 약 4.0배로, 신고 의료기관 수는 약 1.8배로 증가하였다. 검사 현황을 보면 요양병원 전체 양성 검체 중 대변검체 건수가 2020년 2,441건(69.2%)에 비해 2023년 8,558건(73.6%)으로 증가하여 CRE 감염증 환자관리를 위해 선제검사 및 접촉자 검사가 적극적으로 시행되고 있음을 추정할 수 있었다.

요양병원에는 주로 만성질환의 유병률이 높은 고령 환자 및 재활 환자[9]가 장기 입원(전체 평균 재원일수 16.1일, 요양병원 재원일수 평균 134.4일)하고 있으며[10,11], 요양병원의 다인실 구조와 감염관리 인력 및 자원 부족 등으로 인해 CRE 감염 위험이 증가할 수 있다.

우리나라에서도 CRE 감염증 전파 예방을 위한 감염관리

표 3. 2023년 지역별 carbapenemase-producing *Enterobacterales* 감염증 주요 카바페넴분해효소 분포 현황

지역	전체	KPC	NDM	OXA	기타*
계	28,318	21,907	4,487	1,766	158
서울	8,065 (28.5)	5,991 (27.3)	1,436 (32.0)	603 (34.1)	35 (22.2)
부산	2,121 (7.5)	1,738 (7.9)	304 (6.8)	74 (4.2)	5 (3.2)
대구	1,488 (5.3)	1,264 (5.8)	173 (3.9)	40 (2.3)	11 (7.0)
인천	2,425 (8.6)	1,559 (7.1)	652 (14.5)	197 (11.2)	17 (10.8)
광주	706 (2.5)	450 (2.1)	79 (1.8)	176 (10.0)	1 (0.6)
대전	693 (2.4)	506 (2.3)	154 (3.4)	30 (1.7)	3 (1.9)
울산	268 (0.9)	225 (1.0)	34 (0.8)	8 (0.5)	1 (0.6)
세종	28 (0.1)	23 (0.1)	5 (0.1)	0 (0.0)	0 (0.0)
경기	6,780 (23.9)	5,388 (24.6)	988 (22.0)	362 (20.5)	42 (26.6)
강원	539 (1.9)	448 (2.0)	41 (0.9)	48 (2.7)	2 (1.3)
충북	298 (1.1)	229 (1.0)	41 (0.9)	26 (1.5)	2 (1.3)
충남	588 (2.1)	501 (2.3)	71 (1.6)	16 (0.9)	0 (0.0)
전북	960 (3.4)	759 (3.5)	84 (1.9)	111 (6.3)	6 (3.8)
전남	410 (1.4)	273 (1.2)	78 (1.7)	45 (2.5)	14 (8.9)
경북	771 (2.7)	662 (3.0)	98 (2.2)	3 (0.2)	8 (5.1)
경남	2,007 (7.1)	1,743 (8.0)	232 (5.2)	21 (1.2)	11 (7.0)
제주	171 (0.6)	148 (0.7)	17 (0.4)	6 (0.3)	0 (0.0)

단위: 건(%). KPC=Klebsiella pneumoniae carbapenemase; NDM=New Delhi metallo-β-lactamase; OXA=oxacillinase; *기타=Verona integron-encoded metallo-β-lactamase, Imipenemase, Guiana extended spectrum β-lactamase.

대책 마련을 위해 요양병원을 포함한 의료기관의 시설 및 환경관리 체계 개선, 감염관리 제도 기반 확대, 의료관련감염 대응체계 재정비 등 대책을 수립하여 추진 중이다. 또한 지속적으로 감염관리 인력의 역량을 강화할 뿐만 아니라 수가체계 등의 행정적·재정적 지원을 마련해 나갈 예정이다.

국의 분리균 분포와 비교하면 *K. pneumoniae*, *E. coli*와 같이 일부 균만 감시하는 유럽 질병예방통제센터의 경우 국내 감시 기준과 차이가 있어 절대적 비교는 어려우나, *K. pneumoniae*의 카바페넴 내성률은 2018년 8.5%에서 2022년 10.9%로 증가하였음을 알 수 있었다[12]. 세계보건기구(World Health Organization, WHO)는 「WHO bacterial priority pathogens list, 2024」 보고서에서 CRE를 ‘항생제 내성을 예방하고 통제하기 위한 연구·개발 및 공중보건 조치의 우선순위가 가장 높은 중대한 병원체’로 지정하였으며, 항생제 내성균에 대처하기 위해 강력한 감염 예방, 통제 관련 대책 및 새로운 추세 감시, 의약품 개발, 진단·예방 도구 개발 등 국제적 노력이 필요함을 강조하였다[2].

국의 주요 국가들에서도 CRE 감염증 감소 전략으로 의료인은 시설 내 CRE 감염증 발생 위험 요인을 파악하고 대응하며, 감염관리를 위해 손 위생, 개인 보호 장비 착용, 적절한 환경 소독 등을 권고하고, 적절한 항생제 처방 및 사용과 ‘무증상 보균자 선별’을 위한 선제검사를 강조하고 있다[13]. 우리나라에서도 CRE 감염증 전파 예방을 위한 감염관리 대책 마련을 위해 의료기관의 CRE 감염증 실태 조사와 감소 전략 모델 구축·시범 운영 등 현장에서 수용 가능한 대응체계를 구축하고 체계적 감시 및 예방·관리 기반을 마련 중이다.

본 보고서는 CRE 감염증 발생신고서 및 사례조사서를 기반으로 기초통계를 확인하여 감염병의 발생과 분포를 파악하였다. 국내 의료기관에서 CRE 감염증 신고 건과 발생 의료기관 수는 매년 증가하고 있어 적극적인 감시와 더불어 강화된 감염 예방·관리가 필요하며, 정부와 지자체, 의료기관 등이 함께 협력하여 확산을 막기 위한 노력을 지속할 것이다.

Declarations

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Supplementary Materials

Supplementary data are available online.

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Characteristics of Notified Carbapenem-resistant *Enterobacterales* Cases in the Republic of Korea, 2023

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ABSTRACT

Carbapenem-resistant *Enterobacterales* (CRE) infections are increasing worldwide and have become a major public health threat. The Centers for Disease Control and Prevention reported that “the coronavirus disease-19 (COVID-19) pandemic has led to a surge in CRE infections as healthcare facilities have prioritized COVID-19 infection control, making routine infection prevention and control more difficult.” and the World Health Organization estimated 4.95 million people deaths worldwide in 2019 due to antibiotic-resistant bacteria. The annual number of CRE infection cases has been increasing by about 20–30%. In 2023, an analysis of CRE infection reports revealed a total of 38,405 cases, with 55.4% of patients being male. Most cases (65.2%) occurred in individuals aged 70 years and older. Among healthcare facilities, general hospitals had the highest reporting rate at 43.3%. In particular, the number of CRE infection reports in long-term care hospitals and the proportion of total reports increased every year, from 1,077 cases (7.0%) in 2019 to 5,815 cases (15.1%) in 2023. The primary bacteria identified were *Klebsiella pneumoniae* (72.4%) and *Escherichia coli* (14.1%). Among CRE infections, carbapenemase-producing *Enterobacterales* (CP-CRE) infections accounted for 73.7% of all reported cases in 2023, with the proportion of CP-CRE infections steadily increasing every year. Therefore, this study analyzed CRE infection data reported through the Korea Disease Control and Prevention Agency system from 2019 to 2023, thereby providing important insights for the development of effective infection prevention and management strategies.

Key words: Carbapenem-resistant *Enterobacterales*; Carbapenemase-producing *Enterobacterales*; Drug resistance, microbial

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Introduction

The prevalence of carbapenem-resistant *Enterobacterales* (CRE) infections has significantly increased in recent years, posing a major public health threat [1-3]. The coronavirus disease 2019 (COVID-19) pandemic has exacerbated this trend

due to factors such as insufficient healthcare resources, inadequate infection control practices, and increased antibiotic use [4].

CRE infections are caused by *Enterobacterales* that exhibit resistance to carbapenems. Transmission primarily occurs through direct or indirect contact with infected individuals

Key messages

① What is known previously?

Domestic carbapenem-resistant *Enterobacterales* (CRE) infection case have increased by 20–30% every year since 2019. Recently, carbapenemase-producing *Enterobacterales* (CP-CRE) infections accounted for more than 70% of the reported cases, and this proportion is gradually increasing.

② What new information is presented?

Among the CRE (38,405 cases) reported in 2023, the proportion of general hospitals was the highest at 43.3% and the reporting rate of CRE infections in long-term care hospitals increased from 7.0% in 2019 to 15.1% in 2023. The CP-CRE infection rate was 73.7% (28,318 cases), and the number of reporting healthcare facilities increased by 27.4% compared with the previous year (1,117 healthcare facilities).

③ What are implications?

This report provides data for formulating effective strategies for infection prevention and control, while also highlighting that surveillance and infection control are necessary to control the spread of CRE.

or contaminated environments. The likelihood of occurrence is greater in long-term inpatients, those taking immunosuppressive medications, and those with a history of CRE infections [5]. Of particular concern are carbapenemase-producing *Enterobacterales* (CP-CRE), which have emerged as a significant threat in outbreaks due to their ability to transfer resistance genes to other bacteria via plasmids or other mechanisms, enabling rapid transmission [6]. Recent data on CRE infections in the Republic of Korea (ROK) reveal a steady increase in the prevalence of CP-CRE among CRE, highlighting the urgent need for proactive measures to control outbreaks in healthcare settings [7,8].

This report presents a comparative and analytical overview of the incidence and epidemiological characteristics of CRE infections over the past 5 years (2019–2023), aiming to shed light on the evolving patterns of these infections.

Methods

A comprehensive analysis of demographic (sex and age) and epidemiological characteristics (e.g., region, type of healthcare facility, infectious disease patient classification, isolate, carbapenemase type) was conducted. Data were collected from three primary sources: (1) CRE infection case reports, (2) CRE infection investigation reports, and (3) CP-CRE infection case reports. These reports were obtained from the Korea Disease Control and Prevention Agency’s Integrated Disease and Health Management System and span the period from 2019 to 2023. The analysis was based on the reporting dates of infectious disease in healthcare facilities. Results from 2019 to 2022 were drawn from the Annual Report on the Notified Infectious Diseases in Korea and the CRE Infectious Disease Analysis Report [7,8].

Results

1. Carbapenem-resistant *Enterobacterales* Infection Report Status

CRE infection, classified as Class 2 infectious disease, is monitored through a mandatory surveillance system. Since its implementation in June 2017, the number of reported cases has increased by 20–30% annually. In 2023, a total of 38,405 cases were reported from 1,467 healthcare facilities (Table 1).

The demographic characteristics of CRE infections

Table 1. Number of CRE · CP-CRE designated and healthcare facilities by year (2019–2023)

Category		2019	2020	2021	2022	2023
CRE infection	No. of cases	15,369	18,113	23,311	30,548	38,405
	No. of healthcare facilities (place)	831	938	1,067	1,257	1,467
CP-CRE infection	No. of cases	8,887	11,218	14,769	21,695	28,318
	No. of CP-CRE healthcare facilities (place)*	622	670	717	877	1,117
CP-CRE/CRE ratio (%)		57.8	61.9	63.4	71.0	73.7

CRE=carbapenem-resistant *Enterobacteriales*; CP-CRE=carbapenemase-producing *Enterobacteriales*. *Number of healthcare facilities where at least one case of CP-CRE occurred in the year.

Table 2. Characteristics of carbapenem-resistant *Enterobacteriales* (2019–2023)

Category	2019	2020	2021	2022	2023
Total	15,369	18,113	23,311	30,548	38,405
Sex					
Male	8,727 (56.8)	10,210 (56.4)	13,362 (57.3)	17,036 (55.8)	21,293 (55.4)
Female	6,642 (43.2)	7,903 (43.6)	9,949 (42.7)	13,512 (44.2)	17,112 (44.6)
Age group					
0–19	333 (2.2)	311 (1.7)	336 (1.4)	341 (1.1)	456 (1.2)
20–39	513 (3.3)	502 (2.8)	667 (2.9)	784 (2.6)	895 (2.3)
40–49	760 (4.9)	774 (4.3)	1,042 (4.5)	1,246 (4.1)	1,469 (3.8)
50–59	1,789 (11.6)	2,035 (11.2)	2,372 (10.2)	2,914 (9.5)	3,416 (8.9)
60–69	2,943 (19.1)	3,405 (18.8)	4,587 (19.7)	5,864 (19.2)	7,112 (18.5)
≥70	9,031 (58.8)	11,086 (61.2)	14,307 (61.4)	19,399 (63.5)	25,057 (65.2)
Healthcare facility type					
Advanced general hospital	6,266 (40.8)	7,099 (39.2)	9,442 (40.5)	11,737 (38.4)	13,443 (35.0)
General hospital	6,803 (44.3)	8,013 (44.2)	9,786 (42.0)	13,298 (43.5)	16,648 (43.3)
Hospital	1,093 (7.1)	1,380 (7.6)	1,512 (6.5)	1,515 (5.0)	2,105 (5.5)
Long-term care hospital	1,077 (7.0)	1,485 (8.2)	2,383 (10.2)	3,760 (12.3)	5,815 (15.1)
Others*	130 (0.8)	136 (0.8)	188 (0.8)	238 (0.8)	394 (1.0)
Case classification					
Patient of an infectious disease	774 (5.0)	972 (5.4)	1,312 (5.6)	1,897 (6.2)	2,067 (5.4)
Pathogen carrier	14,595 (95.0)	17,141 (94.6)	21,999 (94.4)	28,651 (93.8)	36,338 (94.6)

Values are presented as number (%). *Others=clinic level, dentistry · Korea's traditional medicine hospitals.

reported in 2023 showed that 55.4% (21,293 cases) were male and 65.2% (25,057 cases) were aged ≥70 years. Other age groups included 18.5% (7,112 cases) aged 60–69 years and 8.9% (3,416 cases) aged 50–59 years. Those aged ≥70 years accounted for 58.8% (9,031 cases) of all reports in 2019 and 65.2% (25,057 cases) in 2023, with the proportion increasing annually. Regarding healthcare facility type, 43.3% (16,648

cases) were from general hospitals, 35.0% (13,443 cases) from advanced general hospitals, 15.1% (5,815 cases) from long-term care hospitals, and 5.5% (2,105 cases) from hospitals. In particular, the number and percentage of long-term care hospital reports increased from 7.0% (1,077 cases) in 2019, 8.2% (1,485 cases) in 2020, and 10.2% (2,383 cases) in 2021, 12.3% (3,760 cases) in 2022, and 15.1% (5,815 cases) in

2023.

Furthermore, an analysis of the 2023 notification data according to the CRE infectious disease classification criteria revealed that 5.4% (2,067 cases) of “patients” had CRE detected in blood and 94.6% (36,338 cases) of “pathogen carriers” had CRE detected in clinical specimens other than blood (Table 2).

Of the 38,405 reports of CRE infections in 2023, a total of 36,680 (95.5%) were registered in individual investigation reports, with *Klebsiella pneumoniae* accounting for

72.4% (26,553 cases), *Escherichia coli* 14.1% (5,155 cases), *Enterobacter* spp. 6.0% (2,215 cases), *Citrobacter freundii* 1.9% (681 cases), and *Citrobacter koseri* 1.3% (466 cases) of the isolates. The five most common isolates over the past 5 years have largely maintained their rankings as a percentage of the total from 2019 to 2023. Notably, the prevalence of *K. pneumoniae* has steadily increased since 2019: 60.4% in 2019, 62.6% in 2020, 68.6% in 2021, 70.9% in 2022, and 72.4% in 2023 (Supplementary Table 1; available online).

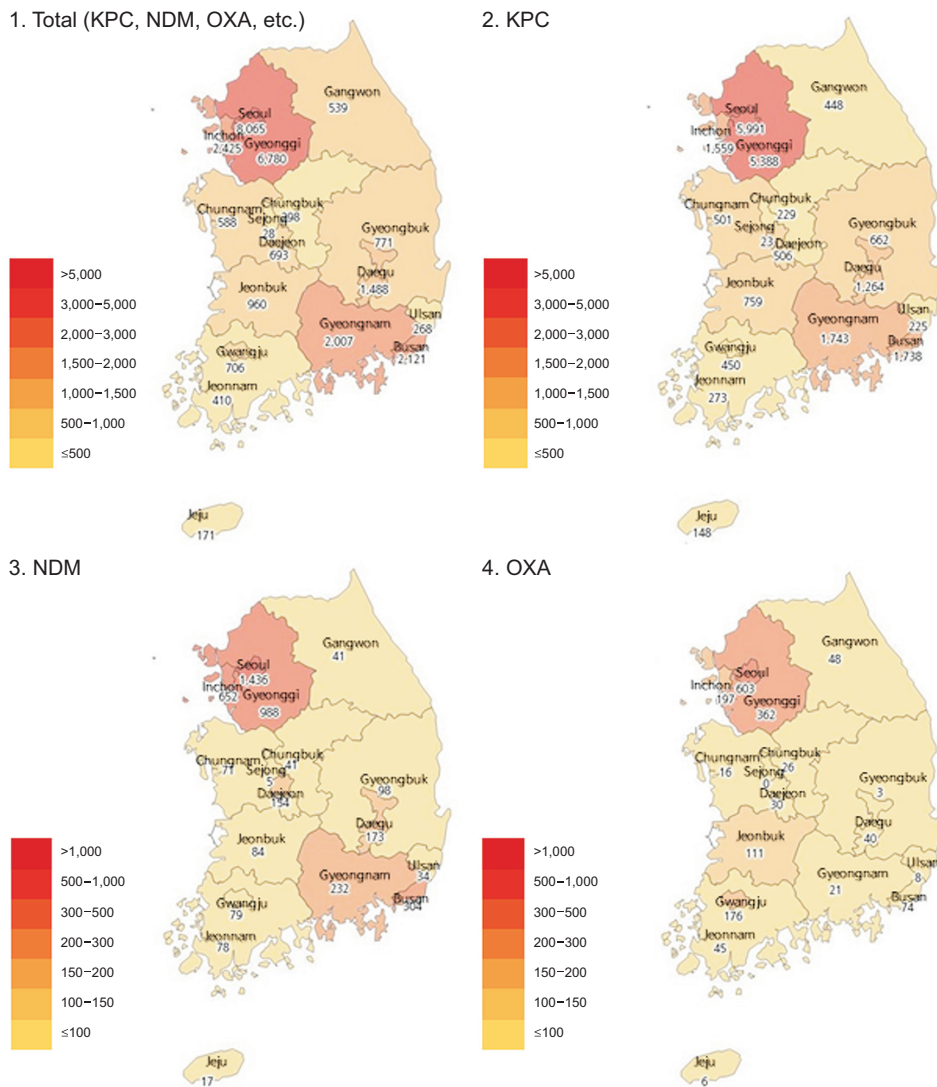


Figure 1. Geographical distribution map of CP-CRE Infection by carbapenemase genotype in region 2023
 CP-CRE=carbapenemase-producing *Enterobacterales*; KPC=*Klebsiella pneumoniae* carbapenemase; NDM=New Delhi metallo-β-lactamase; OXA=oxacillinase; Etc.=Verona integron-encoded metallo-β-lactamase, Imipenemase, Guiana extended spectrum β-lactamase.

2. Carbapenemase-producing *Enterobacterales* Infection Report Status

Of the 38,405 CRE infections reported in 2023, the proportion of CP-CRE infections was 73.7%, with a total of 28,318 cases confirmed in 1,117 healthcare facilities. The proportion of CP-CRE infections increased annually throughout the study period, with 57.8% (8,887 cases) in 2019, 61.9% (11,218 cases) in 2020, 63.4% (14,769 cases) in 2021, 71.0% (21,695 cases) in 2022, and 73.7% (28,318 cases) in 2023 (Table 1).

The distribution of carbapenemases was 77.4% (21,907 cases) for *Klebsiella pneumoniae* carbapenemase (KPC), 15.9% (4,487 cases) for New Delhi metallo-β-lactamase (NDM), and 6.2% (1,766 cases) for oxacillinase (OXA). The three genotypes that have consistently dominated from 2019 to 2023, in

their proportional rankings over time. Notably, since 2019, the proportion of KPCs among all carbapenemases has continued to increase, whereas the proportion of NDMs has decreased (Supplementary Table 2; available online).

A regional analysis of carbapenemases showed that the prevalence of KPC was 27.3% (5,991 cases) in Seoul, 24.6% (5,388 cases) in Gyeonggi-do, and 8.0% (1,743 cases) in Gyeongsangnam-do. The prevalence of NDM was 32.0% (1,436 cases) in Seoul, 22.0% (988 cases) in Gyeonggi-do, and 14.5% (652 cases) in Incheon. The prevalence of OXA was 34.1% (603 cases) in Seoul, 20.5% (362 cases) in Gyeonggi-do, and 11.2% (197 cases) in Incheon (Figure 1, Table 3).

Table 3. Distribution of carbapenemase-producing *Enterobacterales* by carbapenemase genotype in region 2023

Region	Total	KPC	NDM	OXA	Etc.*
Total	28,318	21,907	4,487	1,766	158
Seoul	8,065 (28.5)	5,991 (27.3)	1,436 (32.0)	603 (34.1)	35 (22.2)
Busan	2,121 (7.5)	1,738 (7.9)	304 (6.8)	74 (4.2)	5 (3.2)
Daegu	1,488 (5.3)	1,264 (5.8)	173 (3.9)	40 (2.3)	11 (7.0)
Incheon	2,425 (8.6)	1,559 (7.1)	652 (14.5)	197 (11.2)	17 (10.8)
Gwangju	706 (2.5)	450 (2.1)	79 (1.8)	176 (10.0)	1 (0.6)
Daejeon	693 (2.4)	506 (2.3)	154 (3.4)	30 (1.7)	3 (1.9)
Ulsan	268 (0.9)	225 (1.0)	34 (0.8)	8 (0.5)	1 (0.6)
Sejong	28 (0.1)	23 (0.1)	5 (0.1)	0 (0.0)	0 (0.0)
Gyeonggi	6,780 (23.9)	5,388 (24.6)	988 (22.0)	362 (20.5)	42 (26.6)
Gangwon	539 (1.9)	448 (2.0)	41 (0.9)	48 (2.7)	2 (1.3)
Chungbuk	298 (1.1)	229 (1.0)	41 (0.9)	26 (1.5)	2 (1.3)
Chungnam	588 (2.1)	501 (2.3)	71 (1.6)	16 (0.9)	0 (0.0)
Jeonbuk	960 (3.4)	759 (3.5)	84 (1.9)	111 (6.3)	6 (3.8)
Jeonnam	410 (1.4)	273 (1.2)	78 (1.7)	45 (2.5)	14 (8.9)
Gyeongbuk	771 (2.7)	662 (3.0)	98 (2.2)	3 (0.2)	8 (5.1)
Gyengnam	2,007 (7.1)	1,743 (8.0)	232 (5.2)	21 (1.2)	11 (7.0)
Jeju	171 (0.6)	148 (0.7)	17 (0.4)	6 (0.3)	0 (0.0)

Values are presented as number (%). KPC=*Klebsiella pneumoniae* carbapenemase; NDM=New Delhi metallo-β-lactamase; OXA=oxacillinase; *Etc.=Verona integron-encoded metallo-β-lactamase, Imipenemase, Guiana extended spectrum β-lactamase.

Discussion

The prevalence of CRE infections is increasing both domestically and globally. The Centers for Disease Control and Prevention reported a 35.0% increase in healthcare-associated CRE infections in 2020, coinciding with the COVID-19 pandemic, compared with that in the previous year, as noted in the 「COVID-19: U.S. impact on antimicrobial resistance, special report 2022」 report. This surge peaked in 2021 and persisted above pre-pandemic levels in 2022 [4].

In the ROK, since mandatory CRE infection surveillance began in June 2017, the number of reported cases and reporting healthcare facilities continues to increase. In particular, reports from long-term care hospitals (the number of reporting healthcare facilities) increased markedly from 1,458 cases (322 facilities) in 2020 to 5,815 cases (566 facilities) in 2023. This represents a 4.0-fold increase in cases and a 1.8-fold increase in the number of reporting healthcare facilities. As indicated by the testing status, the proportion of fecal specimens among all positive specimens in long-term care hospitals increased from 2,441 cases (69.2%) in 2020 to 8,558 cases (73.6%) in 2023. This suggests that preemptive and contact testing are being actively implemented to manage CRE patients.

Long-term care hospitals, which primarily admit elderly and rehabilitation patients with chronic diseases, pose unique challenges [9]. The average length of stay in all healthcare facilities is 16.1 days, with an average length of stay of 134.4 days in long-term care hospitals [10,11]. The risk of CRE infection may be increased due to the multi-bedded structure of long-term care hospitals and the lack of infection control staff and resources.

To address these challenges, the ROK is implementing

measures to prevent the spread of CRE infections. These measures include facility and environmental management improvements, including long-term care hospitals, expansion of infection control systems, and reorganization of healthcare-related infection response frameworks. Efforts are also underway to strengthen infection control personnel capabilities through administrative and financial assistance, including reimbursement systems.

A comparison of international isolate distributions with European Centre for Disease Prevention and Control surveillance data for only certain bacteria such as *K. pneumoniae* and *E. coli* reveals discrepancies between the datasets. These discrepancies make absolute comparisons difficult. However, it is notable that the percentages of carbapenem resistance in *K. pneumoniae* increased from 8.5% in 2018 to 10.9% in 2022. These findings suggest that CRE infections are increasing globally [12]. The World Health Organization (WHO) has classified CRE as a “critical pathogen with the highest priority for research, development, and public health action to prevent and control antimicrobial resistance” in its “WHO bacterial priority pathogens list, 2024” report. The WHO also emphasized the need for international efforts to address antimicrobial resistance, including the implementation of robust infection prevention and control measures, the surveillance of emerging trends, the advancement of drug development, and the creation of diagnostic and prevention tools [2].

Global strategies to reduce CRE infections include healthcare providers identifying and mitigating risk factors, emphasizing hand hygiene, personal protective equipment use, and proper environmental disinfection for infection control, and prescribing antibiotics judiciously and conducting preemptive testing for “asymptomatic carriers” [13]. In the ROK, the

government is developing a response system to prevent the spread of CRE infections. This system will be a feasible, on-site one in healthcare facilities to evaluate CRE prevalence and to design and pilot a reduction strategy, establishing a foundation for systematic surveillance, prevention, and management of CRE infections.

The occurrence and distribution of infectious diseases were analyzed using basic statistical methods based on CRE case and investigation reports. This report highlights the growing burden of CRE infections in Korean healthcare facilities, necessitating active surveillance and reinforced infection prevention and control measures. Collaborative efforts among the government, local authorities, and healthcare facilities will be essential to curbing the spread of this significant public health threat.

Declarations

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Supplementary Materials

Supplementary data are available online.

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