

基于自动温度监测的山东省疫苗冷链报警信息分析

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摘要:目的 分析山东省疫苗冷链监测平台中的报警信息, 为提升疫苗冷链保障水平提供科学依据。方法 收集山东省疫苗冷链监测平台内 2024 年 1 月 1 日至 12 月 31 日的超温报警和断电报警信息, 按照季节、地区、单位类型进行描述性分析。结果 山东省冷链监测平台配备安装了 5 463 台数据记录设备和 25 159 个数据采集设备, 实时监测全省 16 地市疾病预防控制中心和预防接种单位的疫苗储存和运输温度。夏季 7 月份的报警信息最多, 平均超温和断电报警数分别为 4.2 条和 2.0 条, 冬季 12 月份的报警信息最少, 平均超温和断电报警数均为 1.1 条。泰安市、日照市和菏泽市的平均超温报警数超过 40 条, 济宁市的平均超温报警数最少为 17.6 条; 滨州市、聊城市、菏泽市和德州市的平均断电报警数超过 20 条, 济南市的断电报警最少(10.1 条)。CDC 的超温报警数最多, 平均超温报警数为 59.7 条; 常规预防接种门诊的断电报警最多, 平均断电报警数为 19.8 条; 狂犬病暴露预防处置门诊的平均超温报警数和平均断电报警数均较多, 分别为 48.2 条和 18.8 条。结论 疫苗冷链报警存在季节、地区和单位类型差异, 应针对性的加强疫苗冷链管理, 保障疫苗安全。

关键词:疫苗; 冷链; 超温; 断电; 报警

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Analysis of vaccine cold chain alarm information based on automatic temperature monitoring, Shandong Province

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Abstract: Objective To analyze the alarm information of monitoring platform for vaccine cold chain in Shandong Province and to provide scientific basis for improving the cold chain guarantee level of vaccines. **Methods** We have collected data on overtemperature and blackout alarms from January 1 to December 31, 2024 in Shandong Province through the cold chain monitoring platform, and descriptive analysis was conducted by season, region, and unit type. **Results** The cold chain monitoring platform in Shandong Province is equipped with 5 463 data recording devices and 25 159 data collection devices, which monitor in real-time the temperature of vaccine storage and transportation in 16 cities' Centers for Disease Control and Prevention and vaccination units throughout the province. The summer month of July has the highest number of alarm information, with an average of 4.2 for overtemperature and 2.0 for blackout alarm. The winter month of December has the lowest number of alarm information, with an average of 1.1 for both overtemperature and blackout alarms. The average number of overtemperature alarms in Tai'an City, Rizhao City, and Heze City exceeds 40, while the average number of overtemperature alarms in Jining City is at least 17.6. The average number of blackout alarms in Binzhou City, Liaocheng City, Heze City, and Dezhou City exceeds 20, while Jinan City has the lowest number of blackout alarms, with an average of 10.1. The CDC has the highest number of overtemperature alarms, with an average of 59.7 alarms. The routine vaccination clinic has the highest number of blackout alarms, with an average of 19.8 alarms. The average number of overtemperature alarms and blackout alarms in the rabies exposure prevention and treatment outpatient department are relatively high, with 48.2 and 18.8 alarms, respectively. **Conclusion** There are seasonal, regional, and unit type differences in vaccine cold chain alarms, and targeted measures should be taken to strengthen vaccine cold chain management and ensure vaccine safety.

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疫苗是需要特定温度条件下储存和运输的生物制品,在不适宜的温度环境中疫苗成分可能会发生物理或化学变化,导致疫苗的效力发生改变,严重时可能构成健康风险^[1-3]。因此,确保疫苗在储存和运输过程中符合冷链管理要求是确保疫苗安全和有效的关键。山东省运用物联网、大数据等先进技术建立起较为完善的疫苗冷链监测平台^[4],实现了对全省范围内疫苗储存和运输的实时监控。本论文通过对山东省 2024 年度疫苗冷链监测平台收集到的报警信息进行分析,旨在探索报警信息的分布规律,为进一步提高疫苗冷链管理的效率和质量提供参考依据。

1 资料与方法

1.1 资料来源 2024 年 1 月 1 日至 12 月 31 日冷链报警数据来源于山东省疫苗冷链监测平台,报警类型包括超温和断电报警^[5]。报警信息按照月份、地市和单位类型(疾病预防控制中心、常规预防接种门诊、常规预防接种站、产科预防接种室、成人预防接种门诊和狂犬病暴露预防处置门诊)^[6]进行分类整理。

1.2 研究方法 对收集到的数据进行整理,计算以下指标:

1.2.1 平均超温报警数 超温报警监测的是探头、温湿度标签的温度情况,因此以单位数据采集设备收集的报警数量作为参考依据。

平均超温报警数 = 平台记录的超温报警数/数据采集设备数

1.2.2 平均断电报警数 断电报警监测的是冷库、冷链室等设施的供电情况,因此以单位数据记录设备的报警数量作为参考依据。

平均断电报警数 = 平台记录的断电报警数/数据记录设备数

1.3 统计学分析 采用微软办公 Excel 2021 软件建立数据库,采用 R 4.4.2 软件对评价指标进行统计分析。

2 结果

2.1 冷链监测设备分布情况 山东省疫苗冷链监测平台在 16 地市安装了 5 463 台数据记录设备,青岛市最多(548 台),东营市最少(153 台);常规预防接种门诊安装的数据记录设备最多(2 636 台),常规预防接种站安装的数据记录设备最少(110 台)。全省配备了 25 159 个数据采集设备,临沂市最多(2 635 个),东营市最少(687 个);常规预防接种门诊安装的数据记录设备最多(16 845 个),常规预防接种站安装

的数据记录设备最少(688 个)(表 1)。

表 1 山东省冷链监测设备分布情况

Table 1 Basic information on cold chain monitoring equipment in Shandong Province

分类	数据记录设备数量(台)	数据采集设备数量(个)
地市		
济南市	488	2 544
青岛市	548	2 249
淄博市	322	1 358
枣庄市	156	797
东营市	153	687
烟台市	440	1 824
潍坊市	526	2 172
济宁市	424	2 298
泰安市	260	1 299
威海市	214	761
日照市	194	731
临沂市	518	2 635
德州市	316	1 463
聊城市	315	1 404
滨州市	218	995
菏泽市	371	1 942
单位类型		
疾病预防控制中心	799	2 034
常规预防接种门诊	2 636	16 845
常规预防接种站	110	688
产科预防接种室	557	1 864
成人预防接种门诊	229	787
狂犬病暴露预防处置门诊	1 132	2 941
合计	5 463	25 159

2.2 报警信息季节分布情况 夏季时超温报警和断电报警较多,其中 7 月份的每个采集设备的平均超温报警数和每个记录设备的平均断电报警数最多,分别为 4.2 条和 2.0 条。冬季时超温报警较少,其中 12 月份(1.1 条)的平均超温报警数最少;秋季和冬季时断电报警较少,其中 2 月份和 10 月份的平均断电报警数均为 1.1 条(图 1)。

2.3 报警信息地区分布情况 泰安市、日照市和菏泽市的超温报警数较多,2024 年每个采集设备的平均超温报警数分别为 44.5 条、42.0 条和 40.7 条;滨州市(25.2 条)、聊城市(25.1 条)、菏泽市(22.0 条)和德州市(20.6 条)、济宁市(17.6 条)。2024 年济南市 2024 年的断电报警最少,每个记录设备的平均断电报警数为 10.1 条(图 2)。

2.4 报警信息单位分布情况 2024 年疾病预防控制中心的超温报警数最多,每个采集设备的平均超温报警数为 59.7 条;常规预防接种门诊的断电报警最多,每个记录设备的平均断电报警数为 19.8 条。另外,

狂犬病暴露预防处置门诊的平均超温报警数和平均断电报警数均较多,分别为 48.2 条和 18.8 条。成人预防接种门诊的平均超温报警数和平均断电报警数最少,分别为 7.6 条和 4.5 条(图 3)。

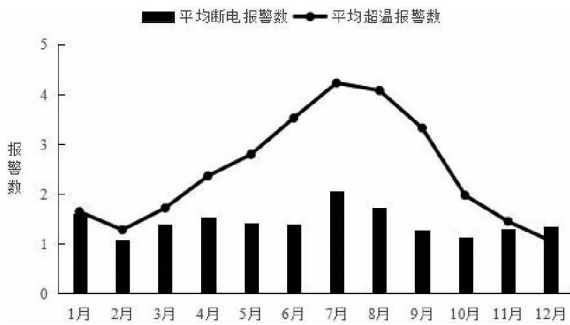


图 1 山东省冷链监测平台报警信息的月分布情况

Fig. 1 Monthly distribution of alarm information on the cold chain monitoring platform in Shandong Province

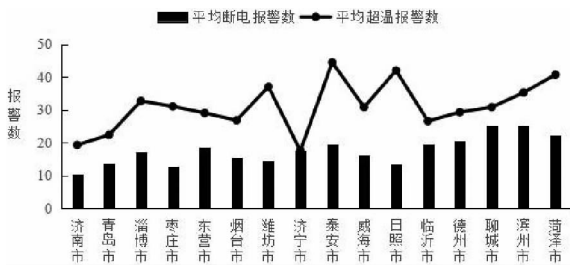


图 2 山东省冷链监测平台报警信息的地区分布情况

Fig. 2 Regional distribution of alarm information on the cold chain monitoring platform in Shandong Province

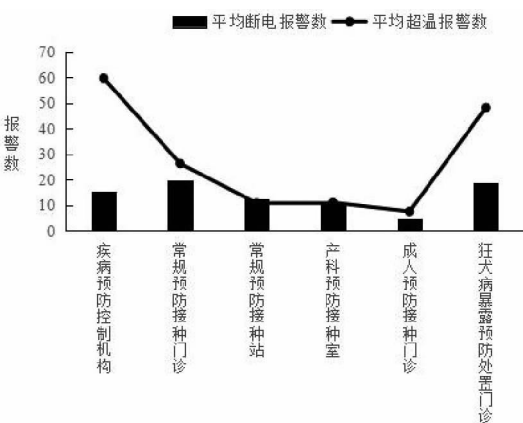


图 3 山东省冷链监测平台报警信息的单位分布情况

Fig. 3 Distribution of unit types of alarm information on the cold chain monitoring platform in Shandong Province

3 讨论

本研究对 2024 年山东省疫苗冷链监测平台的报

警信息进行了统计分析,结果显示,夏季的超温报警和断电报警最为频繁,而冬季的报警较少。季节性的变化趋势在很大程度上反映了环境温度和电力供应对冷链系统的影响。夏季高温导致冷链设备的工作负荷增加而影响制冷效果^[7-8],并且高温时开关设备更容易影响设备内的储存温度,而冬季温度较低时设备的工作负荷相对较小。季节性的波动需要疫苗冷链管理部门给予充分关注,尤其是在高温季节,及时进行设备维护和电力供应保障是确保疫苗质量的关键措施。

泰安市、日照市和菏泽市的超温报警数显著高于其他地市,这种高超温报警可能与当地管理水平、冷链设备的维护状况等有关^[9],经费投入较多地市的冷链设备运行和维护能得到更好的保障,另外人员的规范性操作的培训也能减少人为因素造成的超温报警^[10]。滨州市、聊城市、菏泽市和德州市的高断电报警数可能与当地的电力供应状况有关,这些地市位于鲁西南地区,该地区的电力供应可能受到电网容量和线路维护的影响较大^[11]。而省会城市济南的断电报警数最少,表明济南市在电力供应保障方面做得较好,冷链系统的稳定性较高。

疾病预防控制机构的超温报警数最多,主要与承担的疫苗储存和运输任务繁重和设备使用频率较高有关,尤其是在疫苗装卸过程中,但是设备维护和技术支持水平可能相对较低会导致故障升高。常规预防接种门诊是目前主要的预防接种单位,要从事免疫规划、非免疫规划、成人等各种接种活动^[12],断电报警数最多主要是由于冷链设备较多,需要更大的电力供应保障,而大部分常规预防接种门诊的建设较早,配套设施可能相对落后。成人预防接种门诊是近两年刚开始建设的新的门诊类型^[13-14],通常位于医疗设施较为完善的城区,电力供应和设备维护条件较好,所以超温和断电报警均较少。此外,成人预防接种门诊的疫苗种类和数量相对较少,接种任务较少进一步降低了其报警频率。但是,狂犬病暴露预防处置门诊的平均超温报警数和平均断电报警数均较高,表明在冷链管理和电力保障方面存在较大的改进空间^[15-16]。

疫苗冷链管理应建立定期检查和培训机制^[17-18]。针对超温报警高发的地区和单位,定期对冷链设备进行检查和维修,尤其确保在高温季节能够正常运行。对于断电报警较多的地区,应常备发电机组、增加电力线路维护频率和提高电力设施的抗压能力来减少断电事件的发生,特别是在高温季节。除此之外,还应加强冷链管理人员培训,提高其对冷链设备的管理和维护水平。同时,平台内正着手建立数据

驱动的决策支持系统,充分利用监测平台的大数据构建风险预测模型,并结合对历史数据的挖掘和分析,预测和防范可能的报警事件。

本研究的局限性首先是结果主要关注报警次数,未深入探讨报警的具体原因和影响因素,未来可以结合现场调研和故障分析,进一步明确报警的原因,为改进措施提供更具体的依据。

综上,本研究分析了山东省 2024 年疫苗冷链监测平台的报警信息,揭示了冷链报警信息在季节、地区和单位之间的差异,提出了相应的改进措施,以期能够提高疫苗冷链管理提供参考,确保疫苗的安全性和有效性。

利益冲突声明 本研究不存在任何利益冲突

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